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GOLDEN ANNIVERSARY MEETING
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JUNE 23–27, 1952

American Society for Testing Materials

ASTM BULLETIN

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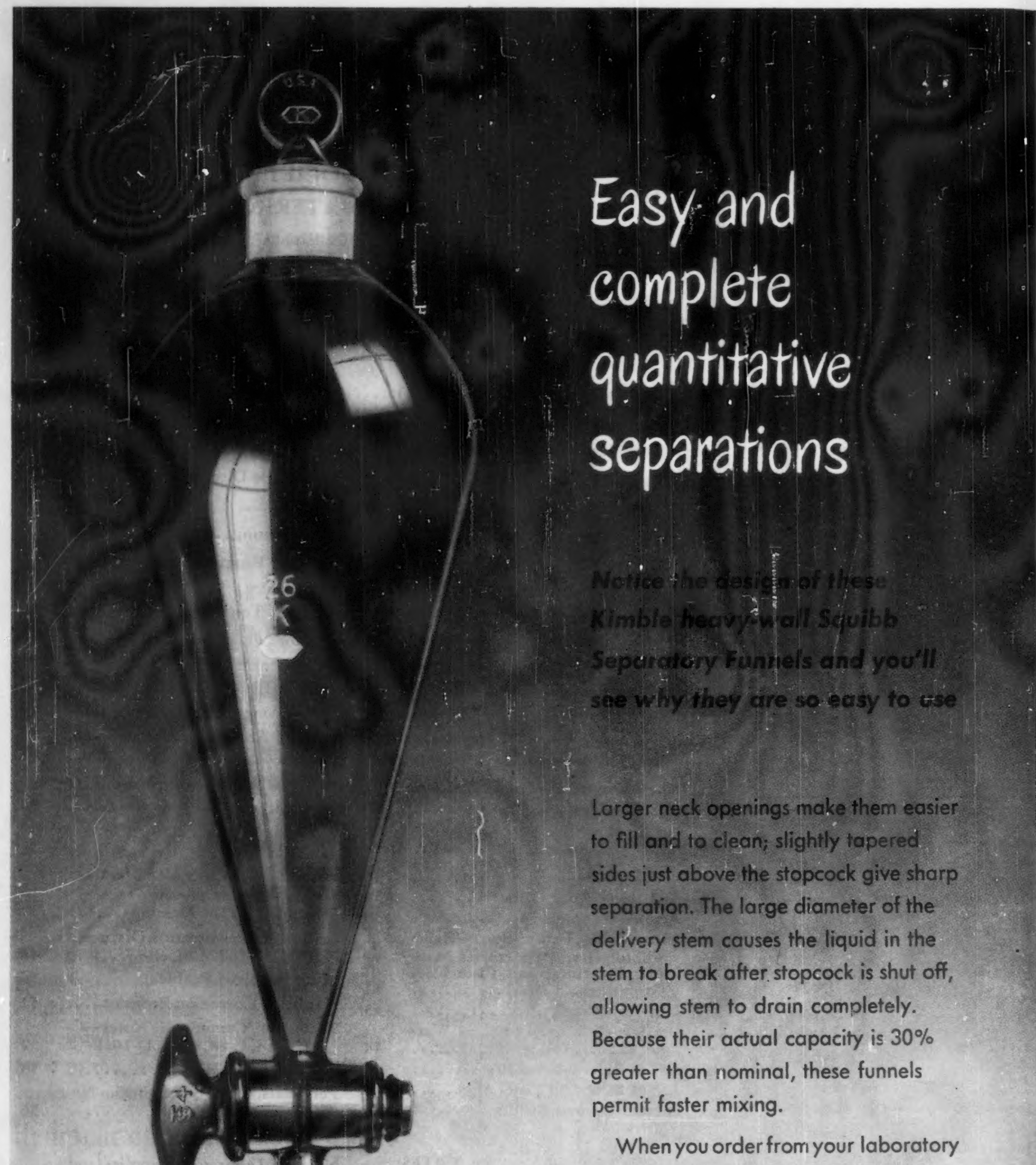

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315 R. E. Hess, Editor CABLE ADDRESS—TESTING, Philadelphia

R. J. Painter, Associate Editor

Number 182 MAY, 1952

C. Laurence Warwick

(1889–1952)

C. Laurence Warwick, for 33 years ASTM's chief administrative officer, died suddenly on April 23, 1952.

Born in Philadelphia in 1889, Mr. Warwick attended the Philadelphia public schools, graduating from Central Manual Training School. In 1909 he received his B.S. degree from the University of Pennsylvania in Civil Engineering. He continued at the University as an instructor and subsequently became an Assistant Professor of structural engineering. During his undergraduate days he had become closely associated with Dr. Edgar Marburg who was ASTM's first secretary from 1902 to 1918.

While on the University faculty, Mr. Warwick assisted Dr. Marburg in ASTM Staff work and was named Assistant Secretary in 1917. In 1919 following the death of Dr. Marburg, he was elected Secretary-Treasurer, a title he held until 1946 when the title of the chief administrative officer was changed to that of Executive Secretary at which time he was elected to that office.

C. Laurence Warwick

Mr. Warwick contributed largely to the technical activities of the Society. One of his first technical services was to succeed Dr. Marburg as secretary of Committee A-1 on Steel. He was at various times a member either in an active or advisory capacity of other technical committees. One of his notable contributions and one in which he took especially keen interest, was his service as chairman of the Administrative Committee on Papers and Publications, which committee is responsible for the technical programs of the Society's meetings. The research aspects of the Society's work also interested him greatly, so much so that he served as ex-officio secretary of the Administrative Committee on Research which serves to coordinate these activities.

At various times he was secretary of a committee for promoting the use of specifications for copper alloys in ingot form; served as secretary of a joint committee on phosphorus and sulfur in steel; chairman of the committee responsible for the Symposium on Malleable Iron Castings; represented the Society in numerous phases of technical work of the American Standards Assn.

Mr. Warwick represented the Society in a number of activities, including the ASME Advisory Board on Engineering Index, the American Marine Standards Committee, the American Association for the Advancement of Science, and others. Special reference should be made to his participation in the work of the ASA. From its inception he had an active, influential part, and made many contributions in the interest of that organization. For a period he was chairman of the Conference of Executives of Organization Members of ASA (CEOM).

Always vitally concerned and interested in assisting the technical branches of the Government and the Armed Forces with their problems, particularly along standardization lines, he had ample opportunity to render valuable service. At the time of his death he was serving as chairman of the ASTM Ordnance Advisory Committee, a post he considered one of his most important responsibilities. In April, 1941, he was asked by the Office of Production Management to come to Washington to assist in establishing on a sound basis the conservation work of the War Production Board. Responding promptly,

the ASTM Directors released Mr. Warwick on a full time and later on a part-time basis to undertake this program. He headed the Specifications Branch of the Conservation Division and directed the National Emergency Steel Specifications Project which proved so effective in conserving critical metals. As the work increased and the staff expanded, Mr. Warwick persuaded a number of ASTM members to participate on leave from their companies.

More recently Mr. Warwick had much to do with the present contract with the Office of Defense Mobilization and ASTM.

In his official capacity he prepared a large number of reports and technical papers, and frequently spoke on engineering materials, standardization, research, and related topics.

Despite his intensive activity in behalf of the Society, Mr. Warwick had numerous other interests. He was a member of the Engineers Club of Philadelphia of which he was at one time director and vice-president and he also headed the engineering alumni group at the University of Pennsylvania.

Beginning in 1937 he was a commissioner of Radnor Township, where he made his home, in later years serving as president of the commission. He held membership in the American Society of Civil Engineers and the American Society for Metals, and was a member of St. David's Golf Club.

Mr. Warwick is survived by his wife, Mary, a daughter, Mrs. Holtzman, and two sons, C. Laurence, Jr., and Robert O., and by his mother, Mrs. Charles F. Warwick.

Burial was at Valley Forge Gardens, King of Prussia, Pa.

C. L. Warwick—the man

MR. WARWICK's death has occurred so recently, and the event is still so unreal, that it is difficult to write coherently on the loss his death represents to the Society, and to the Staff. His influence and leadership in the development of the Society was probably greater than that of any other individual. He literally lived ASTM for the past 33 years—since his election as Secretary-Treasurer in 1919. He thoroughly enjoyed this work and took great satisfaction in it, realizing as he did its great significance and importance in our scientific and industrial structure. He valued too, the association it brought—the working with the leaders and doers in the field of the Society's work.

The Staff loses an outstanding leader, one in whom it could have implicit confidence both with respect to competence and integrity. He was steeped in the tradition set by Dr. Marburg, that of wholehearted cooperation and submergence of the individual's interest for the advancement of the work as a whole. It was group effort that counted. The fostering and adherence to this principle is, without doubt, responsible for the large amount of voluntary and often altruistic effort that has gone into the advancement of the Society's work.

In the host of messages received by 'phone, wire, and letter have been so many expressions such as: "ASTM owes much of its success to him"; "there was a quiet and efficient manner"; "the influence of his work will continue for many years to come"; "a helpful leader and a thorough gentleman"; "a friendly cooperation and a willingness to help everyone"; and many others. One statement that seemed particularly appropriate expressed "a high regard for his capacity as a capable and gifted secretary and a man of innate dignity and loyal friendship."

In a sense the standing and activities of the Society are perhaps the greatest tribute to his productive life.

The fields of standardization and research will have lost one who contributed immeasurably to an appreciation of the importance of this work, and who did as much as any American to advance the use of specifications and tests in the field of materials. A stalwart proponent of sound and intensive research is no more. But the memory of the man, the way he worked, the spirit embodied in his life, will serve as a continued inspiration.

Note of Appreciation

MRS. WARWICK and her family, the Directors and the Staff, wish to extend to all the many members and friends of the Society who sent messages of sympathy and condolence in connection with Mr. Warwick's passing, their appreciation. The number and spirit of these messages have been a source of much comfort to his family and they have further impressed the Board and the Staff with the outstanding nature of the man. Also, they have given much consolation to those who have had to pick up many of the matters formerly handled by the Executive Secretary.

Golden Anniversary Meeting to Feature Extensive Technical Program, Special Lectures and Addresses, Apparatus and Photographic Exhibits

New York City Meeting June 23—27 Includes Laboratory Visits, Interesting Entertainment Program, and Special Events

ENGINEERS and perhaps others are quite prone to indicate the intensive nature of a meeting or explain how complicated an affair is by reference to a 2-, 4-, 6-, or 8-ring circus. In indicating that the ASTM meeting this year is somewhat of a multi-ring circus arrangement, we do not want to imply in any measure that it is a disorganized affair—quite the contrary! Actually the Board of Directors, Committee on Papers and Publications, and especially the New York Committee on Arrangements have devoted much time and effort in correlating the various events.

And even though the program and everything in connection with the meeting is bigger and somewhat more intensive, it is felt the setup is such that a member can take in, without too much complication or conflict, the events constituting his major interests.

The detailed Provisional Program on the following pages of this BULLETIN provides the best advance picture of what is in store. Also there are accompanying articles relating to the Tenth Exhibit of Testing Apparatus and Laboratory Supplies in which over 60 of the country's leading manufacturers and distributors of scientific equipment will show their latest products.

Special features are being arranged for the Photographic Exhibit and Competition including a showing of some 35 unique prize-winners in the 1952 Traveling Exhibit of the Science Section, Photographic Society of America.

37 Technical Sessions
20 Symposiums
75 Exhibit Booths
Extensive Photographic Exhibits
Special Metallographic, Electron Microscope, and Technical Displays
Notable Lectures, Guest Speakers, Foreign Visitors
Special Entertainment Program
Laboratory Visits
Hundreds of Committee Meetings

Two or three ASTM committees in the field of corrosion and appearance are arranging special displays.

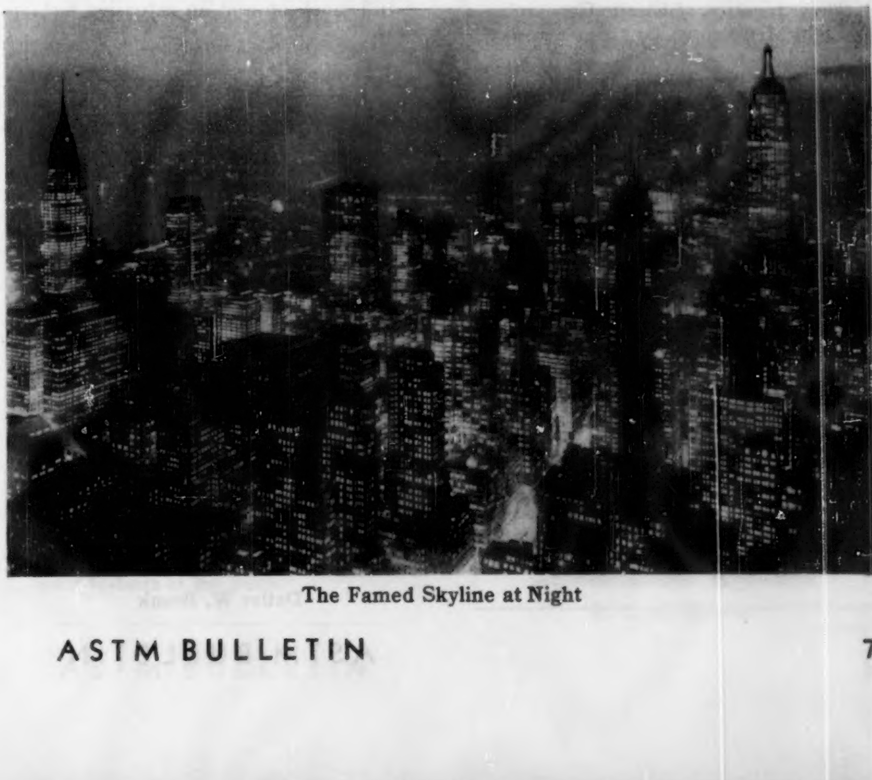
Many of the technical sessions and the exhibits will be at the Hotel Statler. Some sessions and numerous committee meetings will be at the Hotel New Yorker.

Note also the outstanding entertainment program which has been arranged, particularly for the wives and families of members. The New York Committee on Arrangements has sent a special brochure to our members, to acquaint them and their families with this program.

Later in May there will be sent in a special circular to all members and committee members further details and reservation forms to expedite procurement of luncheon and dinner tickets.

Some details of the President's Luncheon and the Dinner Program follow. There are also notes on the Marburg and Gillett Lectures.

But no advance material can cover these features. Our recommendation—come to the meeting and participate in these events. They will highlight 50 years of progress in standardization and research in materials.



The Famed Skyline at Night

New York Committee Message

A SPECIAL brochure has been mailed separately to all members and committee members extending greetings by the General Committee Chairman J. R. Townsend in behalf of Honorary Chairman F. M. Farmer and the committee. The brochure includes details of the most interesting entertainment program developed by Mr. Tour's committee, and there is a special message from the chairman of the committee on promotion, Mr. Freedman, asking help of the members. Accompanying this message is the folder on laboratory visits developed by the committee headed by L. T. Work. The officers and heads of subcommittees of the General Committee are also given.

All of the various subcommittees have been operating intensively. The New York group are really doing what we would call a bang-up job.

Entertainment Program

In the special brochure mailed separately Mr Tour extended greetings to the ladies and families of our members and detailed some of the enticements. The program as outlined at the present time follows:

Symposiums and Other Technical Sessions of Golden Anniversary Meeting

Symposiums

- Testing Adhesives for Durability and Permanence
- Plastics
- Ductility of Metals at Elevated Temperatures
- Continuous Analysis of Industrial Water and Industrial Waste Water
- Determination of Elastic Constants
- Light Microscopy
- Tin
- Exchange Phenomena in Soils
- Direct Shear Testing of Soils
- Application of the Electron Microscope to Metallurgy
- Test Methods for Process Control in Ceramic Whitewares
- Fretting Corrosion
- Conditioning and Weathering
- Recent Developments in Evaluation of Natural Rubber

Other Technical Sessions

- Fatigue
- Factors Affecting Durability of Concrete
- Textiles
- Paint

See Provisional Program in this BULLETIN for tentative scheduling of sessions and abstracts of papers.

Saturday and Sunday, June 21 and 22:

Registration only. Detailed information about New York available at Ladies' Headquarters (air-conditioned Parlors A and B, Hotel Statler). A hostess will be on hand to greet the ladies. She will have full information at her fingertips.

Monday, June 23:

Tea at 3:30 p.m., in the air-conditioned Keystone Room of the Hotel Statler; lecture on "Beauty for Every Woman" with demonstrations of make-up by Charmian Speaker of the Helena Rubinstein Salon and exercise demonstration with explanatory talk by Miss Diana of their "Five Day Wonder School" plus gift favors.

Tuesday, June 24:

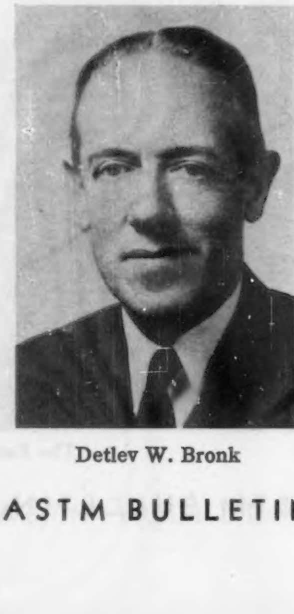
Breakfast at 9:00 a.m. in the Charleston Garden Restaurant on the 8th floor of B. Altman & Co. (one of our great stores) with a lecture on "You, Fashion and Altman's" by Mrs. D. G. Macdougall, Fashion Coordinator, followed by a trip through the store.

President's Luncheon—12:15 p.m. (This includes short addresses by President Fuller, Dr. R. E. Zimmerman, Vice-President, United States Steel Co., and M. Alfred Caquot, internationally famous French engineer, and President, International Standardization Organization, and interesting ASTM ceremonies, in many of which the ladies will be interested. This is scheduled for the air-conditioned Georgian Room.)

Sight-seeing trip around the Island of Manhattan at 3:00 to 6:00 p.m. from the foot of 42nd Street down the Hudson, across New York Bay, up the East River across the Harlem River, and down the Hudson in a ship with glass-enclosed salons.

Wednesday, June 25:

Luncheon and Fashion Show at 12 noon in the famous Cotillion Room of the Hotel Pierre on Fifth Avenue at 61st Street. A full luncheon and an extensive fashion show.



Detlev W. Bronk

In the evening in the Hotel New Yorker's air-conditioned Ballroom and foyers, Cocktail Party, 6:00 to 7:00 p.m. Dinner, 7:00 to 9:00 p.m.; and Dance and Entertainment, 9:00 p.m. to 1:00 a.m.

Thursday, June 26:

Sight-seeing trips in New York City in the afternoon. TV-Radio broadcast tickets for Thursday night.

Registration Notes

Details are being worked out to facilitate ladies' registration expeditiously and conveniently. The New York Committee is underwriting most of the costs so that there will be a registration fee for the ladies of only $5 which will be all inclusive for the week except for the President's Luncheon and the Dinner which are on a subscription basis.

Attractive Dinner Program

The 50th Anniversary Dinner has been planned largely as an informal social gathering, but to be featured by one address by one of our country's leading scientists and educators, Dr. Detlev W. Bronk, President, National Academy of Sciences, and also President, The Johns Hopkins University. We are fortunate in having Dr. Bronk with

Information Desk; Mail; Messages

THE Committee on Information Center, headed by E. P. Pitman, Engineer of Inspection, The Port of New York Authority, will have a special booth manned each day of the meeting to provide information on points of interest in New York, features of our own meeting, and related matters. Considerable literature will be available and a member of Mr. Pitman's committee will be on deck most of the time. This center is aimed to provide not only general information for the members, but also to relieve the main Registration Desk from questions on location and time of meetings and matters of that kind.

The Information Center will also be the focal point for important messages which the group will attempt to relay to our members, but no responsibility is assumed for delivering telephone, telegraph, or other messages. All mail should be directed to the hotel where the member is staying. Mail addressed simply to the meeting will be held at the Information Desk, and can be picked up there. Telephone calls and wire messages will be marked on a bulletin board in the order of receipt.

R. E. Zimmerman

us in view of the extremely heavy schedule he constantly carries. A brief biographical sketch on page 35 of this issue will indicate just how diversified are his interests. Members and their families will not want to miss hearing him.

Following his address there will be dancing for those interested with some special entertainment for those who do not wish to dance. This dinner is in the air-conditioned Ballroom of the Hotel New Yorker.

Cocktail Party

A Cocktail Party will precede the dinner commencing at approximately 5:30 to 6:00 o'clock. Those attending the dinner are to be guests at this party of the New York Committee on Arrangements. It will be a festive occasion designed specifically to have our officers and the New York group meet Dr. Bronk, as many members as possible, and our foreign guests who are expected to be there. Non-diners may participate in the cocktail party at a nominal charge.

It should be emphasized that the New York Finance Group which has received contributions from many of the ASTM company members throughout the country is underwriting all entertainment and related costs. The nominal charge for tickets, to be announced, will simply cover food and service costs.

N. L. Mochel

President's Luncheon

The President's Luncheon this year is a special one designed particularly to welcome the official delegates of the many American societies, associations, and certain Government departments represented at the meeting and to greet delegates of numerous foreign standardizing bodies and other groups. Because of the time factor, the Directors decided to have an outstanding leader from the United States and one from abroad speak for their respective countries. Dr. R. E. Zimmerman, Vice-President, United States Steel Co., an outstanding leader in American technology and industry for many years, will speak on behalf of the many American societies and groups and M. Albert Caquot, famous French engineer, President of the International Standards Organization, will respond for the foreign groups. He is expected to speak in French, with a translation given.

President Fuller's short address will be presented at this meeting, and there will be a few awards and citations made. This is considered an official session of the Society and will be followed by other technical sessions as indicated in the program.

Also, a special broad gage round-table session has been planned in cooperaton with the Conference of Executives of Organization Members of the American Standards Association. A number of ASTM members are active in this group including T. E. Veltfort of the Copper and Brass Research Assn. The session will take the form of three or four short informal chats by top officers of the Society on important aspects of standardization and research in materials. It is expected President Fuller, Vice-Presidents Maxwell and Beard, and one or two others will present talks. There will then be a short question period.

Provisional Program

The Provisional Program of the Golden Anniversary Meeting, outlined on page 19, is designed to give members a comprehensive picture of the sessions, symposiums, and special events of the meeting. Brief abstracts of the papers are provided as well as general statements of the scopes of some of the symposiums.

The official Program which members and guests will receive when they register will contain full and final details of the sessions, a complete schedule of committee meetings, and the when and where of the entertainment features of the week.

Albert Caquot

The Marburg and Gillett Lectures

THE Fiftieth Anniversary Meeting of the Society will mark the occasion of the delivery of the 26th Edgar Marburg Memorial Lecture, by Dr. Robert C. McMaster of Battelle Memorial Institute, and of the first H. W. Gillett Memorial Lecture, by Norman L. Mochel, Manager, Metallurgical Engineering, Westinghouse Corp.

In choosing the subject of the Marburg Lecture, "Non-Destructive, Testing" the directors were aware of the increasing interest in methods of evaluating and testing materials by nondestructive means. Dr. McMaster's outstanding work in that field and his association with ASTM Committee E-7 on Non-Destructive Testing made him a logical choice to receive the invitation to deliver this lecture which is scheduled for Wednesday afternoon, June 25, at 4 p.m.

The Gillett Lecture was established by ASTM in cooperation with Battelle Memorial Institute of which Dr. Gillett was the first Director, to cover subjects pertaining to the development, testing,

R. C. McMaster

evaluation, and application of metals, the fields in which Dr. Gillett was interested.

Mr. Mochel, a director of the Society and Chairman of Committee A-1 on Steel, has selected as his subject, "Man, Metals, and Power." The major portion of his address will be devoted to the use of materials in the field of power generation, including high temperature and related applications and it is also expected that he will give some of the background of the interesting work done by Dr. Gillett.

Joint ASTM-ASA Executives Round-Table Session

ONE of the unusual features of the Annual Meeting is to be a round-table session sponsored jointly by the Conference of Executives of Organization Members of the American Standards Association (known as CEOM), and the Society.

The plan is to have certain of the Society's top officers present, at the relatively short session on Tuesday afternoon at 3 p.m., for brief discussions of certain phases of interesting work in standardization and research. There would then be a question and answer period which would enable those interested in the Society's work and its relation to other organizations and activities to query the men in the panel. Tuesday afternoon was selected as an appropriate time because many of the trade association and Society administrative officers will be present at the President's Luncheon when, as indicated above recognition will be given to the large number of societies who will have official delegates at the meeting.

The CEOM officers are inviting all of their members and others interested, and a general invitation is extended to anyone interested in some of the broader aspects of standardization and research to attend. This is designed as a short, snappy, session. The CEOM activity is one in which the late Mr. Warwick was greatly interested and he served as chairman of the CEOM for a period.

Committee Meetings

Headquarters will not distribute a detailed schedule of committee sessions in advance of the meeting. The listing of technical sessions and committee meetings sent with the hotel reservation form should be considered tentative and members may expect complete information in the official schedule which they will receive from their committee officers. Final details of the schedule are usually not ready until early in June and are printed in full in the official program which members and guests receive when they register.

Invitations have been extended to a number of American, Canadian, and foreign associations to be officially represented at our 50th Anniversary Meeting in New York, June 23–27, 1952.

Among those abroad that will be represented are the following:

Standards Association of Australia, Sydney, Australia
Association Belge pour L'Etude, l'Essai & L'Emploi des Materiaux, Brussels, Belgium
Institut Belge de Normalisation, Brussels, Belgium
Dansk Standardiseringsrad, Copenhagen, Denmark
British Standards Institution, London, England
National Physical Laboratory, Teddington, Middlesex, England
Association Francaise de Normalisation, Paris, France
Suomen Standardisoimisliitto r.y., Helsinki, Finland
Deutscher Normenausschuss, Berlin, Germany
Indian Standards Institution, Delhi, India
UNI Ente Nazionale Italiano di Unificazione, Milan, Italy
Japanese Standards Association, Tokyo, Japan
Savezna Komisija za Standardizaciju, Belgrade, Yugoslavia
Bond voor Materialenkennis, The Hague, Netherlands
Hoofdcommissie voor de Normalisatie in Nederland, 's-Gravenhage, Netherlands
New Zealand Standards Institute, Wellington C.1, New Zealand
Association Suisse de Normalisation, Zurich, Switzerland
International Electrotechnical Commission, Geneva, Switzerland
Schweiz. Verband fur die Materialprufungen der Technik, Neuhausen am Rheinfall, Switzerland

All of these domestic and foreign groups will be recognized at the Presidents Luncheon

Preprints of Papers and Reports

Each member has received from Headquarters a Preprint Request Blank on which he is asked to indicate those papers and reports he would like to receive prior to the meeting. This material will probably be mailed in three installments, the final one just before or during the Annual Meeting. Members and guests who attend the meeting can also obtain copies of preprinted papers and reports or abstracts of items not being preprinted, while registering.

Battelle "Alumni" to Hold Annual Meeting Luncheon

PAST and present members of the staff of Battelle Institute will assemble at luncheon on the opening day of ASTM's Fiftieth Anniversary Meeting in New York.

The luncheon is scheduled for Monday noon, June 23, at the Hotel Statler. That same afternoon Norman L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric Corp., will present the first annual H. W. Gillett Memorial Lecture.

Battelle "alumni" interested in attending the luncheon should make advance reservations by mail with R. O. Stith, Battelle Memorial Institute, Columbus 1, Ohio. Luncheon tickets will be $3.50 per person.

Interesting Paint Committee Program

AS INDICATED in the April BULLETIN, ASTM Committee D-1 on Paint, Varnish, Lacquer, and Related Products is planning several special features to celebrate its Fiftieth Anniversary. Under the direction of J. C. Moore, Director, Scientific Section, National Paint, Varnish and Lacquer Assn., Inc., who is serving as chairman of the D-1 Anniversary Meeting, an interesting technical program has been developed by W. H. Lutz, Technical Director, Pratt & Lambert, Inc. This is to be featured in a symposium on Tuesday afternoon, June 24. A dinner and other events follow that evening. Many D-1 members are cooperating actively, including D-1 Chairman W. T. Pearce, and Secretary C. H. Rose.

ASTM Advisory Corrosion Committee Exhibit

THE first Society-wide corrosion exhibit will be sponsored by the Advisory Committee on Corrosion at the 50th Anniversary Meeting. No exposition is planned of any large-scale tests, but interesting photographic prints in color as well as black and white will be displayed. Actual exhibits of specimens which have been exposed for a number of years will include representative specimens of wire products from Committee A-5, electrodeposited coatings exposed by Committee B-8, and specimens of galvanic couples relating to the work of Committee B-3. The exhibit will be centered around a large-scale map showing ASTM test sites in the United States and Central America. Reports will be available summarizing the corrosion work of the ASTM since it was founded 50 years ago and discussing the activities of the Advisory Committee on Corrosion in establishing and maintaining ASTM test sites.

Members Helping with Annual Meeting Finances

A NUMBER of members of the Society, many of them current or

Esso Laboratories, Linden, N. J.

U. S. Steel Research Laboratory, Kearny, N. J.

These are included in the Laboratory Visits Program, copies of which have been mailed to each member.

former officers, are cooperating closely with Past-President K. G. Mackenzie, Vice-President, The Texas Company, in the procurement of funds to underwrite the Golden Jubilee Meeting. As Chairman of the Finance Committee for the Fiftieth Anniversary Meeting, Mr. Mackenzie has elicited the help of these men in making contacts with specific industrial groups. The personnel of this group includes the following:

M. H. Allen, Structural Clay Products Institute
W. B. Anderson, Titanium Pigment Corp.
B. A. Anderton, Barrett Division Allied Chemical and Dye Corp.
J. W. Bolton, The Lunkenheimer Co.
R. H. Brown, Parks-Cramer Co.
G. H. Clamer, Ajax Metal Division of H. Kramer and Co.
J. L. Crawford, Walsh Refractories Co.
A. R. Ellis, Pittsburgh Testing Laboratory
H. F. Gonnerman, Portland Cement Assn.
G. H. Harnden, General Electric Co.
K. G. Mackenzie, The Texas Company
H. G. Miller, Consultant
R. A. Schatzel, Rome Cable Corp.
D. M. Strickland, National Clay Pipe Manufacturers, Inc.
J. R. Trimble, Tennessee Coal, Iron and Railroad Co.
Stanton Walker, National Sand and Gravel Assn.
R. M. Wilhelm, Miller & Weber, Inc.
W. R. Wilets, Titanium Pigment Corp.
F. P. Zimmerli, Barnes-Gibson-Raymond Division of Associated Spring Corp.
W. A. Zinzow, Bakelite Division Union Carbide and Carbon Corp.

Jerome Strauss, Vice-President, Vanadium Corp. of America, who is Treasurer of the New York Committee on Arrangements, is receiving the various contributions and reports excellent progress toward the goal.

This is the second time that Past-President Mackenzie has been called upon to supervise procurement of funds for a meeting, and he has in his successful record not only a previous ASTM meeting, but a very excellent record in connection with the Diamond Jubilee of the American Chemical Society.

New York's Museums

New York is one of the greatest museum centers in the world. Among its best known are the American Museum of Natural History, the Metropolitan Museum of Art, Brooklyn Museum, the Museum of Modern Art, New York Museum of Science and Industry, and the Museum of the City of New York.

The American Museum of Natural History, Central Park W. and 79th St., houses one of the largest and finest collections of natural science exhibits, including reassembled skeletons of prehistoric animals such as mammoths, mastodons, and dinosaurs; also an interesting illustration of the growth and development of man; antiquities from Mexico, Central America, and the handiwork of the Mayas, Aztecs, and Toltecs.

The Metropolitan Museum of Art, Fifth Ave. and 82nd St., contains the most comprehensive collection of pictures and objects of art in America. The collection, housed in 234 galleries, covers 5000 years and ranges geographically through Egypt, Babylonia, Assyria, Greece, and Rome, the Near and Far East, and Europe, from early Christian to present times. An entire wing is devoted to American decorative arts. The Museum library includes approximately 100,000 books and 200,000 photographs on art and archaeology.

Brooklyn Museum, Eastern Parkway and Washington Ave., is outstanding among American museums for the quality of its collections of the arts and crafts of American, primitive, and Asiatic peoples. It has the largest collection of pre-Spanish, Central and South American art in the country.

The Museum of Modern Art, 11 W. 53rd St., endeavors to further public enjoyment and understanding of contemporary painting, sculpture, architecture, industrial design, theater, dancing, photography, and motion pictures. The Museum's Film Library has two programs daily, at 3 and 5:30 p.m.

The New York Museum of Science and Industry, RCA Building, Rockefeller Center, presents a behind-the-scenes view of the industrial age, exhibit divisions including food industries, textiles, shelter, power, aviation, highway, railroad and marine transportation, communications, machine tools, and electrotechnology.

The Museum of the City of New York, Fifth Ave. and 103rd St., is devoted to the history of New York City from earliest times to present days. The first floor historical galleries, tracing its growth from an Indian village to the present metropolis, include Dutch furniture and portraits and miniatures of early settlers. The second floor contains memorabilia of George Washington and Alexander Hamilton, and shows changing fashions from the Dutch period to the end of the nineteenth century. The third floor displays illustrate the rise of communication.

The Frick Collection, 1 E. 70th St. (New York's only private home where art treasures are assembled and open to the public as a unit) includes paintings by European masters of the 14th to 19th centuries. Sculptures, enamels, Chinese porcelains, and other objects of art also are on display. The mansion (1914) by Carrere and Hastings in the Louis XVI manner, is one of the show places of the city and well worth seeing apart from the art collection.

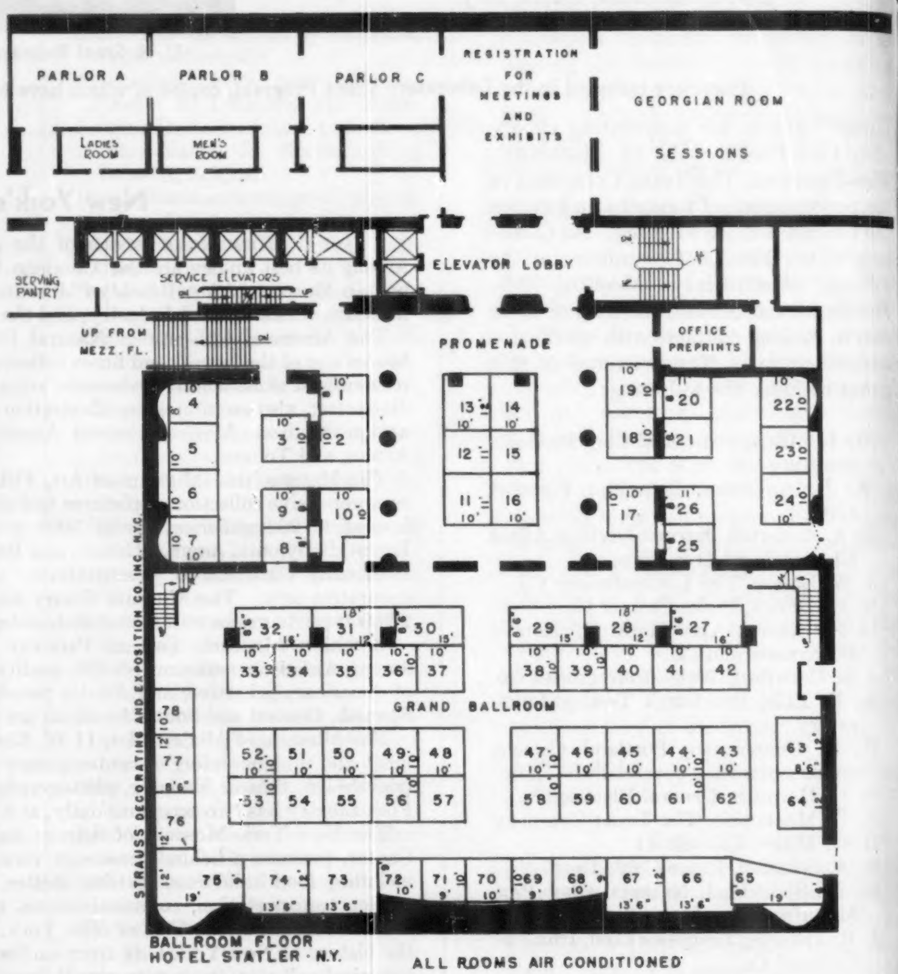
Among other institutions offering interesting exhibits and collections the following might be named: American Academy of Arts and Letters, the National Institute of Arts and Letters, 633 W. 155th St., representing the country's nearest approach to the French Academy, with a permanent exhibit of sculpture, paintings, and manuscripts of its members; American Numismatic Society, Broadway and 156th St.; Museum of the American Indian, Broadway and 155th St., the only organization of its kind in the world, containing an extensive collection of items pertaining to primitive Indian culture; and the Whitney Museum of American Art, 10 W. 8th St., organized for the advancement and appreciation of American Art, and containing collections of paintings, sculpture, drawings, and water colors.

The Dyckman House, 204th St. and Broadway, an excellent specimen of an 18th-century farmhouse, contains a collection of Dutch and English Colonial furniture and curios.

New Instruments Will Feature 1952 Testing Apparatus Exhibit

New Equipment and Laboratory Supplies Will Be Shown by Leading Apparatus Manufacturers and Distributors; in Progress throughout the 50th Anniversary Meeting June 23–27, New York City

ALL concerned with research, testing of materials, and laboratory and production control operations will be interested in attending the 1952 ASTM Exhibit of Testing Apparatus and Laboratory Supplies at the Hotel Statler throughout the week beginning June 23. Many leading manufacturers of apparatus and instruments are participating. A total of 73 booths have already been assigned, making this easily the Society's largest Exhibit to date. Since many special booth displays are being arranged the show should provide a dramatic and informative panorama of progress in this field.



Anyone concerned with the material in the Exhibit is cordially invited to attend. Registration at the Annual Meeting is not necessary, but an Exhibit attendance record is maintained.

During 1952 ASTM, as it is known throughout the world, will celebrate 50 years of service in the field of materials research and standardization of specifications and test methods. Both activities have always been intimately concerned with the apparatus industry, since ASTM Methods and Specifications in almost every instance involve laboratory apparatus to be used. The instrument exhibit serves an important scientific purpose in providing means by which our members may see, at first hand, many of the items of interest to them in their work, whether or not the items are concerned in standardization projects.

The Apparatus displays will be on the ballroom floor occupying the main ballroom, ballroom foyer, and Parlors 1 and 2. Photographic and committee displays are on the ballroom balcony.

The exhibit hours are as follows:

June 23, Monday—12 noon (opening) to 9:30 p.m.
June 24, Tuesday—9:00 a.m. to 5:30 p.m.
June 25, Wednesday—9:00 a.m. to 5:30 p.m.
June 26, Thursday—9:00 a.m. to 5:30 p.m.
June 27, Friday—9:30 a.m. to 1 p.m. (closing)

The short descriptions which follow (based on information supplied by the exhibitors) indicate both the scope of the exhibit and the up-to-the-minute nature of the equipment displayed. In a number of instances the equipment is being shown *for the first time!*

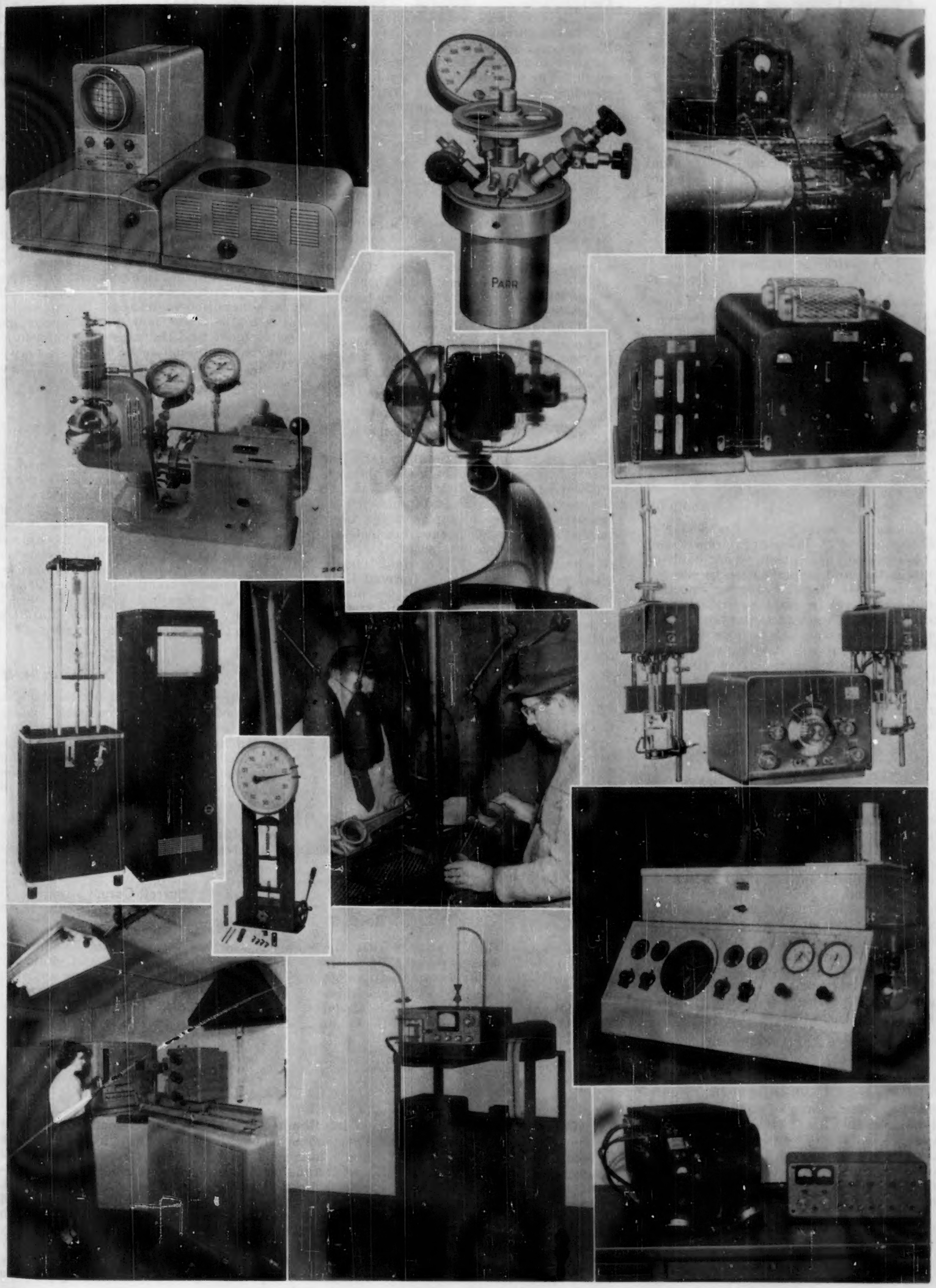
Aetna Scientific Co.

Booth 9

The exhibit will emphasize quality control with special reference to the utmost purity in distilled water and positive sterilization. Water stills will be displayed which not only produce pyrogen-free water but are provided with accessory controls which indicate continually the quality of the water and divert distillate of substandard quality to waste. In this manner, only water of predetermined purity may enter the storage receiver. Welded autoclaves suitable for laboratory use and built in accordance with ASME standards will also be displayed.

Some of the Equipment to Be Displayed in the 1952 ASTM Exhibit of Testing Apparatus and Laboratory Supplies, Hotel Statler, N.Y.C., June 23–27, incl.

First Line, l. to r.: New rapid scanning spectrophotometer; stainless steel pressure reaction bomb; leak detector with pistol grip checking leaks in aircraft fuel cells. Second Line, l. to r.: Bursting strength tester with hydraulic clamp; radiograph of fan using Iridium 192; carbon train for gravimetric determination of carbons-by-combustion. Third Line, l. to r.: Electro-Hydraulic Tensile Tester with electronic recording and control; new spring tester (inset); high-speed inspection by nondestructive method; automatic titrator (above); Flame Photometer for quantitative determination of sodium and potassium (right-hand column, second from bottom). Last Line, l. to r.: Three-meter Grating Spectrograph; Textile Uniformity Analyzer; Recording Oscillograph, and new Bridge Balance.


PARR

American Cystoscope Makers, Inc.
Booth 67

A variety of borescopes for the visual inspection of relatively inaccessible surfaces will be on display. Included will be Model #99A which is intended for the inspection of airplane engine cylinders through the spark plug port. The instrument provides excellent vision because of the unusually brilliant illumination supplied by the miniature lamp. A special feature of this instrument is the two-wire lighting system and the remote control for the lamp to avoid the possibility of igniting residual inflammable gases within the cylinder.

American Instrument Co.
Booth 66

Exhibited will be the new style Climate-Lab with program control of temperature and humidity, Electric Hygrometer for humidity and moisture measurements, Portable Concrete Beam Tester, Barclay Flame Photometer for rapid sodium and potassium determinations, and the Aminco-Gehman Cold-Flex Tester for accurately measuring torsional stiffness, flexure, and permanent set of rubber and similar elastic materials at temperatures from +40 to −90 C.

American Optical Co.
Booth 65

Among the items to be displayed will be the new P45 Polarizing Microscope, a low-priced instrument with built-in illumination and magnification to 430 ×. The new AO Rapid Scanning Spectrophotometer will be displayed which produces spectrophotometric curves instantaneously on the face of a cathode ray tube. This instrument will handle transparent solid or liquid samples up to 100 mm thick. The AO Desk Type Metallograph is used to examine and record photographically the microstructure of metals, measure depth of case and grain size.

The Anderson Machine Shop, Inc.
Booth 8

An exhibit of the Pacific Evenness Tester for quality control in the mill, research, and development of new textile machinery. The tester produces a graph showing the variation of any fibrous material, cotton, woolen, worsted, blends, and synthetics from 8 oz per 5 yds to 1/100 worsted. From this graph can readily be ascertained the weight of material, the average weight for any measured length, the average percentage of variation for any length, the percentage of maximum deviation from the average mean weight of the material being tested, and the average amount that the material is heavier or lighter than the desired weight.

H. Reeve Angel & Co., Inc.
Booth 51

Will exhibit Whatman and Reeve Angel Filter Papers. The feature of the exhibit will be Filter Papers used for paper chromatography, as well as Whatman Ashless Cellulose Powder for use in column chromatography. Chromatography is developing wide application as an analytical tool and interest in it is mounting.

Applied Research Laboratories
Booth 14

An exhibit of ARL spectrochemical equipment commonly used in routine control laboratories. Information concerning the Quantometer is available. The instrument is extremely versatile, performing analysis of various materials. As many as 25 elements selected by user can be accurately measured—up to 20 simultaneously. The Quantometer is invaluable in speeding up production of critical materials and improving laboratory controls. Accurate percentages of elements present are recorded permanently in pen-and-ink in less than two minutes.

Atlas Electric Devices Co.
Booth 32

The Atlas Electric Devices Co. will have on exhibit the latest models of both the Twin Arc and Sunshine Arc Weather-Ometers. The Twin Arc WeatherOmeter on display can be operated either as a Single Arc or Twin Arc Unit for compliance with the various test methods some of which call for exposures with two arcs and others with a single arc. Also on display will be a variety of specimen holders which are available for accommodating various types of materials.

Baird Associates, Inc.
Booths 58, 59

The spectrographic laboratory is finding ever increasing applications wherever qualitative and quantitative analysis are the criteria. Research and industry have accepted the spectrograph on the basis that analysis by spectrographic methods is as good, and often better than wet chemical methods. The 3 Meter Gratin Spectrograph has not only proved itself to be superior in many analyses but it reduces analytical time to minutes instead of hours. This time-saving factor seems to be the essence of better profits in industry and science through better analysis.

Baldwin-Lima-Hamilton Corp.
Booths 73, 74, 75

The theme of the exhibit will be "Electronic Weighing" and several pieces of new BLH electronic equipment will be on display. Included in the exhibit will be a demonstration of shock wave propagation in materials which will include equipment loaned by Cornell University. A newly developed universal SR-4 Testing Machine will be shown and the exhibit will include a conference room in which informal discussions will be possible.

Beckman Instruments, Inc.
Booth 56

Continuous demonstrations with the Beckman DU Flame Spectrophotometer will be held at the Beckman Instruments display booth. Case-history applications of the DU-Flame unit, the portable Model N-2 pH Meter, and the new Beckman Automatic Titrator will be presented. New instruments to be announced include the Beckman High-Frequency Conductometer which measures changes in dielectric constants of liquids and the Beckman Aquameter for determining moisture content of materials.

C. A. Brinkmann & Co.
Booth 62

The exhibit of C. A. Brinkmann & Co. will feature various new developments. Outstanding among these are the Sartorius automatic analytical balances—Selecta. These balances are completely self contained, require no outside weights, and indicate the end result automatically. They are offered in various ranges so as to meet the different requirements in routine and research work. Also on display will be a new line of balances developed for the textile trade, new photomicrographic equipment, and the latest development in microscope design in the form of the Zeiss-Winkel Standard Microscope with built-in light source.

The Brush Development Co.
Booth 55

This firm will exhibit the Uniformity Analyzer, a tool for checking and grading uniformity of yarn, roving, and sliver at high speeds. Operation is nondestructive to material tested, and graphic record of measurement is provided. The Strain Analyzer graphically records mechanical strains in the order of 10 microinches per inch. The Surface Analyzer furnishes an instantaneously available and permanent record of magnified profile of surface finishes. Faxfilm Comparator furnishes additional information on surface finish.

Buehler Ltd.
Booths 34, 35

The new abrasive cut-off machine, a floor model with recirculating cooling system for small samples will be exhibited for the first time. Other items also in operation will include the new Speed Press, the Electro Polisher, optical equipment, laboratory presses, polishers, and grinders. A special feature will be the selected items of Swiss-made Amsler testing machines including the paint tester, temperature controller, small tension tester, and the piston ring tester.

Burrell Corp.
Booths 15, 16

Burrell shows new high-frequency equipment for gravimetric and volumetric determinations of carbon and sulfur by combustion; apparatus for gas analysts; box-type furnaces for high temperatures; and the versatile Burrell Wrist-Action Shaker.

First Diagonal Line, lower l. to upper r.: Simulated weather tester; electro polisher for various types of metallurgical specimens; industrial telescope for inspection of inaccessible surfaces. Second Diagonal Line, lower l. to upper r.: Abrasive cut-off machine for small samples; unit for determining sulfur in ferrous metals; universal wear tester; new automatic analytical balance; new type laboratory stirrer. Third Diagonal Line, lower l. to upper r.: Fabric tester of impact type for use on doped aircraft surfaces; accelerated oxidation tester for transformer oils; electronic tensile tester; water still. Fourth Diagonal Line, lower l. to upper r.: New variable transformer; spectrographic laboratory including: Projection Comparator-Densitometer, Spectrograph, and Source unit; X-Y Recorder for precision analysis. Bottom Line, l. to r.: A 15,000-lb universal testing machine; Rockwell Hardness Tester; Hydrostatic pressure generator for testing pressure vessels.

Carlson Co.
Booth 68

Two new instruments introduced to the public for the first time will be featured. The Carlson Spring Coiler makes samples and small lots of compression, extension, and torsion springs in quantities from 1 to 1000 easily, quickly, and accurately. The Carlson-Chatillon Spring Tester tests loads and deflections of compression and extension springs with extreme accuracy. Four sizes are available: 25, 100, 200, and 300-lb capacities.

Central Scientific Co.
Booth 43

A new moisture balance designed for quick and accurate determinations of moisture in a wide variety of materials will be shown. Moisture content of foundry sand, detergents, and other industrial products may be determined. Readings are direct in moisture from 0 to 100 per cent in steps of 0.2 per cent. Another most practical and useful routine tool is the new Cenco-Lerner Lab-Jack which provides the laboratory with an all-purpose, general utility support that is light in weight, sturdy, and compact. Utilizing the scissors-jack principle, the Lab-Jack permits quick, accurate adjustment of height over a wide range. The maximum platform height is 10¼ and the minimum 2¾ in.

Consolidated Engineering Corp.
Booths 48, 49, 50

Latest developments in Consolidated instruments for the recording and measurement of vibration, stress, strain, pressure, acceleration, etc., will be in the CEC booth. This equipment is widely used in aircraft, railroad, and automotive industries. Demonstration of the Consolidated Leak Detector will be of especial interest to representatives of refrigeration and other companies requiring accurate tests of vacuum or pressure. Consolidated's Titrilog, widely known as a monitor for gas odorization, will be exhibited also in its use as an aid to air pollution studies.

Corning Glass Works
Booth 45

Corning Glass Works will display a variety of items of Pyrex, Vycor, and Corning brand glassware. One item of special interest will be tubing with an electrical conducting surface. This surface makes possible a controlled uniform temperature within the tubing making it suitable for heating columns, condensers, and so on.

Curry & Paxton, Inc.

Booth 26

On Exhibit: Lovibond Tintometers, Lovibond Schofield Tintometers, Lovibond Comparators, "Ogal", Fused Glass Precision Laboratory Cells, Color Measuring Apparatus.

Custom Scientific Instruments, Inc.
Booth 69

This firm, manufacturers of scientific laboratory equipment and instrumentation in the electromechanical field, will display the following items: CSI Stoll Quartermaster Universal Wear Tester, CSI Stoll Flex Tester, and SPI Flammability Tester in the textile, plastic, rubber, etc. fields; CSI Templin Calibrator in the mechanical field; and CSI High Speed Angle Centrifuge in the chemical field.

J. W. Dice Co.
Booth 64

Unusual nondestructive and physical testing and measuring instruments will be shown by this company. Latest model ultrasonic and magnetic instruments for the inspection and test of metals and other materials will be exhibited. Also shown will be a new line of Electronic Micrometers which will afford measurements to 0.000020. These Electronic Micrometers are used for measuring both compressible and noncompressible materials, either conducting or nonconducting in nature.

Doble Engineering Co.
Booth 52

A new accelerated oxidation test for determining the oxidation characteristics of new, used, and re-refined transformer oils and a laboratory clay treater for estimating on samples, the re-refining required for large volumes of oil will be shown in operation. The water extraction set for determining the moisture content of insulating oil and the latest in the Doble line of power factor test equipment for solid and liquid insulation will also be displayed.

Eastman Kodak Co.
Booths 11, 12

Display will feature Kodak Industrial X-Ray Films, Chemicals, and Accessories for use in the nondestructive internal examination of materials by X-ray and gamma ray radiography. Distillation Products Industries, a division of Eastman Kodak Co., will display high vacuum equipment for assuring leak-free systems. This will include the Halogen-Sensitive Leak Detector, Type LD-01, the Consolidated Mass Spectrometer Leak Detector, and the 10 Port Vacuum Manifold System.

Eldorado Mining and Refining Ltd.
Booth 77

Exhibit will consist of radioelements used as radiography sources. Particular emphasis will be given to high specific activity, pile produced Iridium 192. The soft gamma rays (0.209 to 0.608 MEV) from Iridium make it suitable for rapid inspection of thin heavy metal sections, and thicker sections of lighter metals. Radiographs of thicker sections of the heavy metals will also be exhibited, illustrating the use of both compressed radium and high specific activity cobalt 60.

Fisher Scientific Co.
Booth 29

Among the items to be displayed are: Fisher-Tag Union Colorimeter for determining the color of lubricating oils and many petroluem products. Made in accordance with ASTM D 155 and U. S. Government Method 10.22. Fisher-Tag Robinson Colorimeter for precise determination of color shade of lubricating oils. Fisher-Tag Open Cup Flash Point Tester for determining the flash point of mobile liquids flashing below about 175 F. Fisher-Tag Closed Cup Flash Point Tester for determining flash point of all mobile liquids flashing below 175 F. Applicable to lacquer solvents and diluents of low flash points, but not products classed as fuel oils. Fisher-Tag Daylight Lamp for use in ASTM color determinations for use with Saybolt or Robinson colorimeters. Fisher Induction Carbon Apparatus, an integrated unit for rapid, precise, determination of carbon content of steel and other metals. Fisher Isotemp Bath, an electronically controlled constant temperature bath, of unusually high precision.

General Electric
Booths 46, 47

This organization's booth will have in operation three new testing instruments: the Type H Leak Detector, for locating leaks in pressurized vessels; the fatigue tester, actually fatigue testing a specimen; and an ultrasonic generator, set up to demonstrate the action and effects of ultrasonic vibrations. Also on hand will be the metals comparator, gel-time meter, and surface resistance indicator.

General Radio Company
Booth 19

Exhibit will include (1) apparatus for measuring the properties of dielectric specimens over a wide frequency range; (2) a new a-c operated, direct-indicating megohmmeter for insulation resistance measurements; (3) a polariscope for stress measurements under both static and dynamic conditions; and (4) a new line of sound and noise measuring instruments for the determination of machinery noise, surveys of environmental noise, and measurements to determine the possibility of hearing impairment in factory employees working in noise locations.

General Scientific Equipment
Booth 6

The Barclay Flame Photometer and the Patwin Electro-Polarizer will be displayed by this firm. The first is a low-priced easily operated instrument for rapid and accurate quantitative determination of sodium and potassium. Determinations are accomplished with a simple d-c circuit and a sensitive external galvanometer. The Electro-Polarizer is a new instrument for research and routine analysis of chemical compounds. An outstanding feature is a built-in standard cell which allows accuracy of the instrument to be checked while the instrument is being used.

William J. Hacker & Co., Inc.
Booth 71

Exhibited will be: Universal Camera Microscope, a versatile and compact unit; Kofler Micro Cooling Stage, for microscopic observation of processes at controlled temperatures ranging from −55 to +80 Celsius; Kofler Micro Heating Stage, for microscopic observation at temperatures from 20 to 340 C; and Kofler Hot Benches, determine melting points of organic substances within a few seconds. Other instruments to be displayed include the new Reichert Half-Shadow Polorimeter.

First Line, l to r: Apparatus for precise comparison of prepared emulsion formulations; electronically controlled constant temperature bath; universal testing machine. Second Line, l. to r.: Universal Camera Microscope; Direct Reading Megohmmeter for measurements of insulation resistance; Surface Coating Analyzer (under first two items in this row); simulated weather tester with program control of temperature and humidity; Electronic Micrometer. Last Line, l. to r.: Simulated washing machine for testing soaps and detergents; New Radium beam director; Absolute Pressure Controller and Magnetic Contact Adjuster.

Hanovia Chemical and Mfg. Co.
Booth 42

(Report on display not available at time of publication.)

Instron Engineering Corp.
Booth 40, 41

This firm will exhibit its Model TT-B electronic tension testing instrument. This equipment features a choice of full-scale load ranges that extends from 2 g to 1000 lb. Various accessories such as compression fixtures and jaws will be shown, together with the new Automatic Integrator for evaluating areas under the load-elongation curves.

Jarrell-Ash Co.
Booth 17

On exhibit: Jaco "Speclab," a low-cost complete unit for spectrochemical analysis consisting of Grating Spectrograph, Excitation Source Microphotometer, and all needed accessories. Also, high-aperture Hilger Raman Spectrograph with pivotable cameras of aperture F/1.5 and F/5.7 for analyses and structural studies.

Leeds & Northrup Co.
Booth 28

Around the theme "Precision Analysis with Instruments" Leeds & Northrup has set up four demonstrations illustrating precision analysis. (1) The versatile adjustable-range, adjustable-zero Speedomax Recorder shown with load cells; (2) a resistance thermometer recorder which operates with the same precision as laboratory resistance bridges; (3) a two-pen Speedomax having two separate electronic balancing systems housed in one case; (4) a new pH indicator, line operated and fully stabilized.

Lindberg Engineering Co.
Booth 57

The exhibit will feature the new Lindberg Sulfur Determinator being used in conjunction with the "H-F" combustion unit for the determination of sulfur in all ferrous products in accordance with recognized ASTM E 30 – 47. The ability of the "H-F" unit to completely fuse samples of high-nickel alloys, high-chrome alloys, and other materials whose fusion point is above the temperature range of resistant element furnaces has opened a new field of application for the "Sulfur-by-Combustion method."

Magnaflux Corp.
Booth 76

Nondestructive testing, and inspection in a wide variety of methods and applicable to any solid or porous materials, will be presented by Magnaflux Corp. Inspection results in locating defects will be shown and demonstrated. Trained field engineers will be present to furnish detailed information on Magnaflux Duovec, multi-directional magnetic particle inspection. Information supplied on laboratory inspection at eleven Magnaflux Laboratories, or field inspection anywhere. Process control data and information on maximum savings from testing will be supplied.

Micro Metallic Corp.
Booth 33

This firm will exhibit stainless steel filter material in various fabricated units and the latest advances in "Surfamax" and "Gravatain" elements as well as new smooth type filter sheets; also their line of laboratory funnels, crucibles, gas tubes, spargersall stainless steel construction. The firm expects to have an actual unit in operation at the show.

H. R. Moore Co.
Booth 21

The Moore Surface Coating Analyzer to be displayed is a precision tool for measuring the gelation times and progressive drying characteristics of air drying coatings. It utilizes the rolling ball principle in determining these properties by timing the rate of descent of a steel ball between two points one meter apart on an inclined plane. Rapid tests are facilitated by automatic timing, built-in levels, dial indicator for angle adjustments and a metal rack for drying films applied to both sides of the plates.

National Forge & Ordnance Co.
Booth 38

Shown will be a 15,000-lb TMU-B Universal Testing Machine with recorder and accessories along with the new triple range Izod-Charpy Impact Tester for plastics, ceramics, die-casting alloys, etc. Accessories and instruments shown by National Forge are the Vericolumn, an improved elastic calibrating device for testing machines, and a new Extensometer. The 1000-lb capacity Compression-Flexture Tester for containers, wallboard, and plastics will be on display.

National Spectrographic Labs., Inc.
Booth 3

(Report on display not available at time of publication.)

North American Philips Co., Inc.
Booth 78

Company will display their new water-cooled X-ray Diffraction apparatus together with the wide range High and Low Angle Goniometer and Electronic Circuit Panel. The Scaling Circuit and Rate Meter are also included. A new Fluorescence Analysis unit will be introduced providing quantitative and qualitative analysis of chemical elements with atomic numbers in a range lower than previously attained. The Philips Electron Microscope will be shown and its many inviting features—principally its Direct View Screen and resolution—should be investigated by all interested in this science.

Tinius Olsen Testing Machine Co.
Booth 30

This company will have on exhibition the 120,000 split cabinet Super L Universal Testing Machine with electronic recorder and multirange load cell. Also they will have on exhibition Universal instruments, extensometers, simplified bolt testing equipment, and other accessories.

Parr Instrument Company
Booth 44

Several new oxygen bombs for calorimetry and for oxygen combustion tests will be featured. These include a new self-sealing micro oxygen bomb, a new high-pressure oxygen bomb for testing explosive materials, and a double-valve bomb for high-precision calorimetry. The standard single-valve and double-valve Parr self-sealing oxygen bombs will also be shown, together with the Parr adiabatic oxygen bomb calorimeter for solid and liquid fuels. Also shown will be the Parr Series 4500 stirrer type pressure reaction apparatus.

B. F. Perkins & Son, Inc.
Booth 5

Booth will feature the Mullen Bursting Strength Tester. In addition to the models so widely used in the paper, textile, and fiberboard industry, there will be a first showing of newly developed types for: The fibre container industry—Model A Tester with Hydraulic Power Clamping; sheet metals industry—a bursting strength tester with a 2500 psi maximum capacity; sheet plastics industry—Vinyl Film Burst Tester; and paint and varnish industry—Distention Potential Testers for wood finishes. Of special interest will be the display of a 69-year-old Mullen Tester, one of the first of its kind ever built.

Picker X-Ray Corp.
Booth 70

The latest accessories and equipment available for x-ray work will be on display. A staff of technical specialists will assist visitors with any x-ray planning or technical problem.

Radium Chemical Company, Inc.
Booth 39

This firm will exhibit material pertaining to radiography with radium. Radiographs taken by means of the gamma rays will be on display and information pertaining to these radiographs will be available from the technical representative at the exhibit. Radium capsules, lead shipping and storage boxes, and the new radium exposure calculator will be demonstrated. In addition, the new Radium Beam Director will be exhibited for the first time in this country.

Riehle Testing Machines Division
American Machine and Metals, Inc.
Booth 27

On exhibit will be: Model PS-5 Universal Screw Power Type Testing Machine, featuring five-scale range indicating unit, variable speed electronic drive and high magnification stress-strain recorder. New model of Combination Izod-Charpy-Tension Impact Testing Machine for capacities of 30 to 240 ft-lbs with infinitely variable height of pendulum drop feature.

Milton Roy Company
Booth 72

The Hydrostatic Pressure Generator on exhibit operates on plant air and develops pressures up to 25,000 psi. The air applied to a reciprocating piston in the air cylinder causes the stroking of the pump which pumps any clear liquid into a vessel to be tested. When the pressure inside the vessel reaches a predetermined level it balances the air pressure applied to the air cylinder and the pump ceases operation. If the vessel leaks and the pressure inside drops, the pump will again begin intermittent operation to maintain the desired pressure level. The "miniPump" pumps in a controlled volume, from 3 to 3200 ml per hour of any clear liquid. It operates against pressures as high as 1000 psi.

Scott Testers, Inc.
Booth 10

The exhibit will center around three machines. Two of these are new: the new Scott Strain Tester, having its first public showing at this Convention, and the new Inertialess Weighing System known as "Accro-Meter," a Conversion Kit for converting existing Scott Testers from constant-speed-of-pull to constant-rate-of-extension. Also on display will be the latest model NBS Mooney Viscometer, world standard tester for viscosity and scorch characteristics of natural and synthetic rubbers.

Sperry Products, Inc.
Booth 18

Two of the latest model ultrasonic reflectoscopes will be demonstrated in operation. The use of the equipment in testing a number of different types of samples will be shown.

Steel City Testing Machines Inc.
Booth 63

This firm will exhibit and demonstrate for the first time anywhere a new Impact Type Fabric Tester developed in conjunction with the Civil Aeronautics Administration for use on fabric-covered aircraft control surfaces. The instrument tests the strength of doped fabric on the aircraft and is intended to provide a "go and no go" method of determining whether or not the surface being tested is sufficiently strong to pass minimum CAA requirements. Also to be shown, in operation, are representative models from among the company's well-known line of Testing Machines, including Brinell Hardness Testers, a Ductility Tester, and a Direct Reading Proving Ring.

The Superior Electric Company
Booths 53, 54

Display features representative samples of the standard line of voltage control equipment. Of special interest is the new "Powerstat" variable transformer type 10, the modern answer to variable a-c voltage control of 50, 100, and 150-w loads. The display also includes "Stabiline" Automatic Voltage Regulators, type IE (Instantaneous-Electronic) and type EM

(*Continued on p. 61*)

This Program is Subject to Change

All time indicated is Eastern Daylight Saving Time

Provisional Program

FIFTIETH ANNIVERSARY MEETING

of the

AMERICAN SOCIETY FOR TESTING MATERIALS

NEW YORK, N. Y. JUNE 23 TO 27, 1952

All Technical Sessions at Statler Hotel

Committee Meetings held throughout the week at Hotels New Yorker and Statler

	MONDAY, June 23	TUESDAY, June 24	WEDNESDAY, June 25	THURSDAY, June 26	FRIDAY, June 27
Morning	*1st* Strength and Ductility of Metals at Elevated Temperatures *2nd* Tin	*7th* Continuous Analysis of Water (Report D-19) *8th* Fatigue with Emphasis on Statistical Approach *9th* Conditioning and Weathering	*16th* Light Microscopy (Report E-1) *17th* Determination of Elastic Constants *18th* Fretting Corrosion *19th* Fatigue (*cont.*) (Report E-9)	Interpretation of Non-Destructive Tests *24th* Adhesives (Report D-14) *25th* Durability of Concrete *26th* Textiles (Report D-13)	*34th* Exchange Phenomena in Soils (Report D-18) *35th* Report Session—D-2, D-3, D-11, D-12, D-15, D-16, D-17, D-21, 11:30 a.m.
Afternoon	*3rd* Strength and Ductility of Metals at Elevated Temperatures (*cont.*) *4th* Tin (*cont.*) *5th* Gillett Memorial Lecture 4:00 p.m.	*10th* President's Luncheon: Address, Brief Ceremonies, Honors, Awards Joint Session, ASTM-ASA CEOM *11th* Analysis of Water (*cont.*) *12th* Fatigue (*cont.*) *13th* Electron Microscope (Report E-4) *14th* Paint	*20th* Light Microscopy (*cont.*) *21st* Fretting Corrosion (*cont.*) *22nd* Papers on Non-Ferrous Metals (Report B-5) *23rd* Marburg Lecture 4:00 p.m.	Interpretation of Non-Destructive Tests (*cont.*) *27th* Plastics (Reports D-6, D-9, D-10, D-20) *28th* Shear Tests on Soils *29th* Rubber	*36th* Test Methods for Process Control in Ceramic Whitewares (Report C-21)
5 p.m.		*15th* Reports A-1, A-2, A-6, A-7, A-9, Jt. Comm. Ef. Temp, C-13, D-7, E-2, E-3 E-7		*30th* Reports C-2, C-3, C-8, C-11, C-14, C-16, C-17, C-18, C-19, C-20, C-22, D-1, D-5, E-6 *31st* Reports B-1, B-2, B-3, B-4, B-6, B-7, B-8, B-9, E-5	
Evening	*6th* Strength and Ductility of Metals at Elevated Temperatures (*cont.*) Insulating Oil (at meeting Comm. D-9)		Cocktail Party 5:30 p.m. Anniversary Dinner 7:00 p.m. Guest Address Dancing	Interpretation of Non-Destructive Tests (*cont.*) *32nd* Concrete (Reports C-1, C-7, C-9, C-12, C-15, D-4, D-8) *33rd* Corrosion and Creep of Metals (Reports A-3, A-5, A-10)	

Monday, June 23 9:30 a.m. First Session

Held simultaneously with the Second Session

Opening Session

Symposium on Effects of Notches and Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures

Formal Opening of the Fifty-fifth Annual Meeting. President T. S. Fuller.

Approval of Minutes of 1951 Annual Meeting.

Symposium on Strength and Ductility of Metals at Elevated Temperatures

In the past several years, considerable interest has developed regarding the effects of notches on metals at elevated temperatures, under either static or dynamic loading, and it is therefore appropriate that the Joint ASTM-ASME Committee on Effect of Temperature on the Properties of Metals should sponsor a symposium at which the results of current research may be presented and discussed.

The symposium will also deal with another aspect of the behavior of metals at elevated temperatures, namely, the metallurgical changes which occur during heating at elevated temperatures, and the effects of these on strength and ductility.

A Survey of Embrittlement and Notch Sensitivity of Heat-Resisting Steels. George Sachs and W. F. Brown, Jr., Lewis Flight Propulsion Laboratory, National Advisory Committee on Aeronautics.

The German and English literature regarding the creep embrittlement of heat-resisting steels is reviewed. Effects on the impact strength of heating with and without an applied low stress are discussed. The work of Thum and Richard on creep damage is analyzed to reveal more clearly the influence of applied stress and creep time on both the creep damage and permanent damage. The influence of notches in stress-rupture tests on heat-resisting steels is discussed and it is suggested that both creep damage and notch-rupture sensitivity are manifestations of the same phenomena. An attempt is made to determine the effects of alloy composition on both creep damage and notch-rupture sensitivity.

Effect of a Notch and of Hardness on the Rupture Strength of "Discaloy." F. C. Hull, E. K. Hann, and H. Scott, Westinghouse Electric Corp.

Certain components of jet engines require materials of low notch sensitivity at elevated service temperatures. In a commercial austenitic alloy, the effects of hardness as varied by titanium content have been related to the behavior of the material in the notched condition. Creep-rupture and notched-bar rupture tests were conducted at 1000 and 1200 F. The plain-bar rupture strength reached a maximum at a hardener content producing 2 per cent rupture strain and the notched-bar strength exceeded the plain-bar strength in material in which the creep specimen had more than 5 per cent rupture strain.

The Influence of Sharp Notches on the Stress Rupture Characteristics of Several Heat-Resisting Alloys. W. F. Brown, Jr., M. H. Jones, and D. P. Newman, Lewis Flight Propulsion Laboratory, National Advisory Committee on Aeronautics.

Stress-rupture data are reported for tests on sharply notched and unnotched specimens of several heat-resisting low-alloy steels, ferritic stainless steels, and austenitic alloys. Tests were made at several temperatures within the preferred range of application for these materials. Presence of a sharp notch is shown to severely weaken many of these alloys. This weakening effect is not necessarily related to the ductility of the unnotched specimen. Severe notch weakening is, however, always associated with an extremely brittle fracture of the notched bar. The time-temperature dependence of the notch brittleness strongly suggests that it is due to a precipitation reaction. An attempt is made to explain the observed results on the basis of what is already known regarding the effects of notches.

The Effect of Grain Size Upon the Fatigue Properties at 80, 1200 and 1600 F of the "Precision-Cast" Co-Cr-Ni-W Alloy X-40. P. R. Toolin, Westinghouse Electric Corp.

Variations in the pouring temperature and cooling rate of castings result in metallurgical-structure variations, of which the most obvious is in grain size. These variations occur in commercial practice and the effect of them upon the fatigue properties is of interest to those who use cast members under variable stress conditions. This paper deals with the effect of these variations upon the unnotched and notched, completely reversed "stress," fatigue strength at 80, 1200, and 1600 F of a "precision-cast" cobalt-chromium-nickel-tungsten alloy variously known as AMS 5382, Alloy X-40, and Stellite No. 31.

(Continued in Third and Sixth Sessions)

Monday, June 23 9:30 a.m. Second Session

Held simultaneously with the First Session

Symposium on Tin

Tin is the only major common metal not covered by ASTM specifications. Subcommittee III of Committee B-2 on Non-Ferrous Metals and Alloys has been asked to look into the feasibility and desirability of preparing specifications for this metal. It became evident that a great deal of misinformation existed on tin, partly because of marketing conditions, stock-piling and the need for importing practically all tin.

Consequently, a symposium on tin has been arranged to obtain factual information. The object of this program is to consider some of the most important problems, such as a better understanding of tin resources and production capabilities, some of the conservation measures being undertaken, the field of greatest use in tin coatings, and problems in analysis.

Tin Production and Resources. F. Stuart Miller, Pacific Tin Co.

Present trends of tin production in all the principle producing countries are summarized. Over 60 per cent of the world's tin continues to come from Malaya, Indonesia, Thailand, and Burma. The two chief methods of production in this area, dredging and gravel pump mining, are outlined briefly. Consideration of the tin resources of the chief producing countries leads to the conclusion that there will be ample supplies of tin for commercial purposes at approximately the present rate of consumption for a number of years to come, provided only that political conditions are sufficiently stable for tin mining to be feasible. Illustrations in the form of colored slides showing mining operations in Malaya and Thailand are to accompany this paper.

Tin Coatings. Frederick A. Lowenheim, Metal and Thermit Corp.

Fields of usefulness of tin coatings in industry will be surveyed, and the methods of application reviewed. Particular emphasis will be placed upon electroplating methods.

The influence of the purity of the tin upon these applications will be considered. There is very little information on this subject, but such as there is will be offered. One aspect of this topic is coming into some prominence in connection with the so-called "tin-pest."

Trends in the Use of Tin in the Container Industry. Robert R. Hartwell, American Can Co.

While tin has certain characteristics which have so far made tin plate unique as a container material for moist food products, circumstances have produced a long-term downward trend in its consumption per unit of tin mill products. The developments producing this trend are summarized, the technical obstacles now retarding further tin conservation are indicated, and it is concluded that the trend toward lower tin coatings has not yet ended.

Solders in the Automotive Industry. Homer Pratt, General Motors Corp.

(Continued in Fourth Session)

Monday, June 23 2:00 p.m. Third Session

Held simultaneously with the Fourth Session

Symposium on Effects of Notches and Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures (*Continued*)

Investigations into the Effect of Notches on The Results of Long-Time Rupture Tests at the Elevated Temperatures. W. Siegfried, Sulzer Bros., Ltd.

Tests are described which were carried out on smooth and notched specimens of a high-temperature steel with various times-to-rupture, likewise a series of long-time rupture tests conducted with models of blade roots of the same metal. The results obtained throw some light on the practical significance of embrittlement phenomena. In further creep tests on smooth and notched bars of various high-temperature steels, carried out at 600 C, the formation of the crack was observed by metallographic means. The interpretation of the test results permits certain conclusions to be drawn as to the relationships existing between notch brittleness and the elongation figures of the smooth specimens.

Theory of Time Dependent Rupture and Interpretation of Some Stress-Rupture Data. D. N. Frey, Ford Motor Co.

Metallurgical factors influencing rupture test elongation are discussed for several austentic "super" alloys. The discussion is in terms of two probable mechanisms of time-dependent rupture and some relationships between rupture time and notch sensitivity are then pointed out in terms of these mechanisms.

Emphasis is also put upon tensional relaxation with elastic follow-up carried to rupture. Under such conditions there is a linear relation between the reduction of stress concentration by plastic (creep) deformation.

Effect of Notch Geometry on Rupture Strength at Elevated Temperatures. E. A. Davis and M. J. Manjoine, Westinghouse Electric Corp.

Three series of creep rupture tests of notch bars with varying geometry of the notch were performed at elevated temperatures on several heat-resistant alloys. The effect of notch sensitivity of the following was also investigated: stress level, grain size, hardness, ductility, and heat treatment. Increasing the sharpness of the notch with constant depth notches may raise or lower the notch sensitivity depending on the ductility and microstructure of the alloy. The size effect or effect of shank diameter can be practically eliminated by using a "standard" notch geometry. The notch sensitivity is accentuated by increasing the depth of the notch to about one-fourth of the shank diameter. It is postulated that the fracture originates just below the surface at the root of the notch.

(Continued in Sixth Session)

Monday, June 23 2:00 p.m. Fourth Session

Held simultaneously with the Third Session

Symposium on Tin (*Continued*)

Effect of Trace Alloying Elements on the Allotropic Transformation of Pure Tin. Frederick J. Dunkerley, University of Pennsylvania.

A review of the literature on the effect of residual or trace metallic elements on the allotropic transformation of pure tin from the white (β) to the gray (α) form will be presented. Major emphasis will be placed on delineation of the effects on the rate of the transformation of those elements which are found in commercially pure tin as a result of existing methods of extraction, reclamation, and refining. Using these evaluated data, specifications for pure tin on the basis of its intended use will be set forth.

The Determination of Small Amounts of Impurities in Tin. Marie Farnsworth and Joseph Pekola, Metal and Thermit Corp.

Improvement in the quality of pig tin has necessitated improvement in the analytical methods used for its control. For example, in *Metal Statistics* for 1919, the quality of grade 1 tin is listed as 99.86 per cent, while, in 1952, tin of 99.97 and 99.98 per cent purity is available commercially. Special refined tin of even higher purity is available in limited quantity.

Analytical methods have kept pace with the improvement in quality of the product. Colorimetric (and, for certain elements, chemical) methods of analysis for the following impurities are described: antimony, arsenic, lead, bismuth, copper, iron, silver, sulfur, cobalt, nickel, cadmium, zinc, and aluminum. Particular attention is paid to the elimination of interference by impurities which are normally present in refined tin.

Panel Discussion—Analysis of Tin. (In cooperation with Committees E-2 and E-3.)

Monday, June 23 4:00 p.m. Fifth Session

Gillett Memorial Lecture

First Gillett Memorial Lecture—Man, Metals, and Power. N. L. Mochel, Westinghouse Electric Corp.

This lecture, jointly sponsored by ASTM with Battelle Memorial Institute commemorates Horace W. Gillett, one of America's leading technologists, the first director of Battelle, and for many years a very active worker in the Society. It will be delivered annually at a Society meeting. Mr. Mochel will include in his lecture a background of some of the interesting work done by Dr. Gillett, some biographical information, and in keeping with Dr Gillett's broad interest, the evaluation of metals and alloys, will devote a considerable portion of the lecture to the use of materials in power generation including high-temperature and related applications.

Monday, June 23 8:00 p.m. Sixth Session

Symposium on Effects of Notches and Metallurgical Changes on Strength and Ductility of Metals at Elevated Temperatures (*Continued*)

An Experimental Study of the Strength and Ductility of Steel at Elevated Temperatures. J. Glen, Colvilles Ltd., Technical Offices.

By tempering a steel for various times at a given temperature and creep testing there is an increase in creep resistance with short tempering times and a decrease with more prolonged tempering. This phenomenon appears to be related to that of precipitation hardening. To prove this true stress-strain tension tests were carried out on a series of low-carbon steels containing varying amounts of manganese and molybdenum and the effect of structural changes (precipitation) during straining studied. From this work it was possible to explain the effect of alloying elements and structural changes on the creep properties of ordinary steel.

Effect of Sigma on Strength and Ductility of 25 Cr, 20 Ni Steel. G. V. Smith and E. J. Dulis, United States Steel Co.

Specimens of 25 Cr, 20 Ni austentic stainless steel, initially cold worked some 35 per cent, were heated at 1700, 2000, or 2300 F for 1 hr and water quenched, then exposed for 7500 hr at 1300 F to promote the precipitation of sigma phase. Tests were then made in comparison with unexposed metal. In room-temperature tension tests, sigma caused increased yield and tensile strengths and reduced ductility. Sigma also resulted in severe loss of notch impact strength at room or lower temperature.

Creep-rupture tests at 1300 F showed sigma to be slightly deleterious to strength, except at very short rupture time or fast creep rate in the case of metal initially annealed at 2300 F. At sufficiently long test time, the unexposed and exposed metal may have similar properties.

Recovery and Creep in an Alloy Steel. H. A. Lequear and J. D. Lubahn, General Electric Co.

The Structure and Properties of Stainless Steels After Exposure at Elevated Temperatures. A. B. Wilder and E. F. Ketterer, National Tube Co.

A number of ferritic and austenitic stainless steels were exposed at temperatures of 900 to 1200 F for periods up to 34,000 hr. Microstructure of the weld-heat-affected zone and parent metal, tensile and creep-rupture properties of the parent metal are discussed.

The tensile properties at ambient temperature of several steels were changed after exposure for 10,000 hr. The creep-rupture strength at 900, 1050, and 1200 F in certain steels was changed after 10,000 hr exposure at the elevated temperatures. Ductility in rupture tests of the ferritic steels was increased and in the austenitic steels decreased when compared with the tension test results at ambient temperature. Sigma was observed in all the ferritic steels except 12 Cr, FM and possibly 12 Cr, Al after 34,000 hr exposure at 1200 F. Sigma was observed after exposure at 1200 F in all the austenitic steels except 25 Cr, 12 Ni which was exposed for only 5000 hr.

Exploratory Investigation of High-Temperature Sheet Materials. D. Preston, General Electric Co.

The purpose of this project was to determine the high-temperature mechanical properties of several materials commercially available in sheet form. The materials investigated included three iron-base strain-hardening-type alloys, three iron-base age-hardening-type alloys, and three cobalt-base alloys which are used in the annealed condition. Microstructures are discussed and creep, stress-rupture, and short-time tension and yield data are presented for these alloys from room temperature to 1800 F.

Tuesday, June 24 9:00 a.m. Seventh Session

Held simultaneously with the Eighth and Ninth Sessions

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water

Introduction. B. W. Dickerson, Hercules Powder Co.

The proper operation of industrial water and waste treatment works requires control based on chemical analyses which must be made by laboratory personnel.

With the increase in labor costs, emphasis is being placed on the use of automatic equipment for control and analytical determinations.

The Advisory Sub-Committee of D-19 on Industrial Water have felt that a symposium on continuous analysis should be held and with this in mind has arranged a program to cover pH, oxidation, reduction potential, conductivity, alkalinity, acidity, chlorine residual, oil, hardness, turbidity, silica, and dissolved gases.

Automatic Sampling of Industrial Water and Industrial Waste Water. M. F. Madarasz, Ford Motor Co.

The principles of sampling industrial water and industrial waste water are discussed. Present analytical methods, with a high degree of accuracy and precision, make it necessary to strive for the same standards in sampling. The successful sampling program includes objective, proper sampling location, thorough knowledge of the process, method of obtaining a sample, and selection of a material which will not contaminate the sample. The data obtained depend on the duration and frequency of the sampling. The advantages and disadvantages of manual, composite proportioned, and continuous methods of sampling are also discussed.

Some Practical Aspects of the Measurement of pH, Electrical Conductivity and Oxidation-Reduction Potential of Industrial Water. Robert Rosenthal, Industrial Instruments, Inc.

Industrial growth has brought with it increasing dependence upon automatic devices for measurement and control of composition of plant influents and effluents, including water and waste. pH, electrical conductivity, and oxidation-reduction potential where applicable, provide reliable indices of ion concentrations. pH measurements are widely applied in treatment of industrial wastes. Conductivity instruments serve to gage total ion concentrations and are widely used in many aspects of steam generation. Oxidation-reduction potential measurements have scarcely been put to use in continuous testing of industrial water. Service limitations for these electrometric measurements are usually quite specific in each field of application.

Report of Committee D-19 on Industrial Water. Max Hecht, Chairman.

(Continued in Eleventh Session)

Tuesday, June 24 9:00 a.m. Eighth Session

Held simultaneously with the Seventh and Ninth Sessions

Fatigue with Emphasis on Statistical Approach

The Statistical Nature of the Fatigue Properties of SAE 4340 Steel Forgings. J. T. Ransom, E. I. du Pont de Nemours and Co., and R. F. Mehl, Carnegie Institute of Technology.

The fatigue properties of SAE 4340 gun tubes were investigated by procedures which permitted statistical analysis of the variability of the endurance limit and the life to failure. The variability of fatigue properties was found to be greater than usually estimated from the results of conventional nonstatistical testing procedures. This was true even in high-quality forgings in which the strength and ductility properties were very uniform. The variability was significantly greater in the transverse direction of forgings which had low average transverse ductility. The variation in life to failure resulting from the unavoidable variation in several experimental factors was shown to be insignificant.

The Statistical Behavior of Fatigue Properties and the Influence of Metallurgical Factors. E. Epremian and R. F. Mehl, Carnegie Institute of Technology.

While it has been well established that the fatigue properties of metals are statistical in nature, the influence of metallurgical factors on this behavior has not been known. The dependence of fatigue variability on such factors as composition, microstructure, hardness, and inclusion rating has not been evaluated, and it was toward this objective that considerable experimental work was directed.

The statistics of the fracture curve and endurance limits were obtained for a variety of materials, and analysis and comparison of the results by statistical methods indicated the influence of the metallurgical variables on the statistical behavior; it has been found that the most important single factor in determining the extent of the variability in fatigue properties is the inclusion content.

An Analysis of Scatter in Fatigue Testing. Frank A. McClintock, Massachusetts Institute of Technology.

A New Interpretation of the Understressing Effect. E. Epremian and R. F. Mehl, Carnegie Institute of Technology.

The subject of the understressing effect in fatigue has been studied experimentally and theoretically from a statistical point of view. It has been shown that the effect can, in part if not wholly, be interpreted as a statistical phenomenon based on selectivity and the statistical nature of the endurance limit. Contrary to general belief, cold-work does not play a dominant role in the behavior, but the specific extent of its influence must be evaluated by further research.

Many other conclusions with regard to the fatigue of metals which have been previously accepted, should be re-examined by using the necessary statistical approach.

Fatigue Properties of Large Specimens with Related Size and Statistical Effects. O. J. Horger and H. R. Neifert, Timken Roller Bearing Co.

This paper summarizes the results of rotating bending fatigue tests on shafts 0.3 in. to 7 in. in diameter from SAE plain carbon steels 0.41 C to 0.52 C, in both the "as-forged" and normalized and tempered condition. Shafts were tested with stress concentration, as represented by both fillets and press-fitted members, as well as plain specimens.

Shafts with stress concentration produced by fillets or press-fitted members from either untreated or normalized and tempered material exhibited little or no size effect. An endurance range of 17,500 to 25,000 psi was found from tests on 120 plain specimens 6 in. in diameter of untreated steel, while filleted shafts (r/d = 0.14 and 0.29) of the same material had endurance limit values within this range. A similar comparison exists on normalized and tempered steel, but here less extensive data are available.

(Papers on Fatigue Continued in Twelfth and Nineteenth Sessions)

Tuesday June 24 9:00 a.m. Ninth Session

Held simultaneously with the Seventh and Eighth Sessions

Symposium on Conditioning and Weathering

Fundamentals of Atmospheric Elements. Benarthur C. Haynes, United States Weather Bureau.

The general effects of weather on erosion and deterioration of materials have long been recognized but only in the last few years has it been possible to relate cause and effect by direct measurements. To provide some guidance on the use of meteorological parameters in developing criteria for the design of exposed materials, methods of measuring atmospheric elements are described. The variations in weather elements from day to day, month to month, and even year to year require careful consideration in the evaluation of weathering tests. When a test site is located even at a small distance from the meteorological observation point, variations in local weather may often be important.

Textiles. Robert H. Brown, Parks Cramer Co.

Conditioning and Weathering of Paper. William R. Willets, Titanium Pigment Corp.

The main atmospheric component in the conditioning of paper is relative humidity which determines moisture content. This moisture acting as a plasticizer affects strength, rigidity, and plasticity. Changes in moisture content produce dimensional changes in the fibers which in turn are translated into over-all dimensional changes in the sheet.

Examples are given showing the importance of relative humidity in testing, specification, converting, and end use. Other conditioning and weathering factors are discussed.

Conditioning and Weathering of Adhesives and Plastics. Frank Reinhart, National Bureau of Standards.

The general principles concerned with conditioning and accelerated weathering of plastics and adhesives are considered. The topics discussed include reasons for such tests, variations in procedures, interpretation of results, selection of specific tests for particular purposes, defects inherent in such tests, correlation with actual aging and weathering, and the effects of these procedures on the properties of plastics and adhesives.

Weathering of Some Organic Coatings. E. J. Dunn, Jr., National Lead Co.

There are perhaps thirty types of physical and chemical changes going on within a paint film as it weathers. Good weathering of a paint film requires an unusual balance or compromise of these physical and chemical forces. Many of these forces have been measured, and the rate of change of these forces in the aging film appears to dictate the useful life of the film.

The importance of such factors as relative humidity, uniformity of film, film thickness, film shrinkage, moisture sorption, pigmentation, amount of film applied and physical structure on film properties are illustrated. Graphs are presented to illustrate the changes in some of the physical properties as the film ages. To eliminate confusion where many film properties are summarized, a numbering system is suggested as a means of attempting a single over-all film rating figure for comparing the integrity of films.

Metallic Coatings. William Blum, National Bureau of Standards.

Laboratory Air Conditioning. A. E. Stacey, Jr., Carrier Corp.

The paper discusses the different types of laboratories, the varied air-conditioning problems inherent in each and in laboratories in general, and the methods of solving these problems. It points out that each laboratory will present its own special problem requiring its own special air-conditioning solution.

In analyzing problems and solutions, it covers the following points: (1) sources of heat and the use of dew point control and varying air volume to handle the heat load and maintain a constant humidity, (2) methods of distributing air in the spaces to be conditioned, including a description of each type of outlet, its operating characteristics, advantages, and disadvantages, (3) effect of exhaust hoods, particularly where noxious fumes are present, (4) location of ducts, risers, and other connections between main apparatus and room outlets, (5) method of control in rooms and central apparatus, and (6) location of main apparatus.

Small Scale Conditioning. C. P. Lascaro, Signal Corps Engineering Laboratory.

Outdoor Exposure Testing on Racks and Test Fences. K. G. Compton, Bell Telephone Laboratories.

A description is given of the physical structure of outdoor exposure racks and test fences and the principal factors to consider in their location. A consensus of experience is given as to the effect of the direction which the specimens face and the angularity with respect to the horizontal plane. Further discussion is given as to the effect of the location of the specimens with respect to nearness to ground, sheltering from wind, the top of buildings, proximity to industrial contamination, etc. The influence of geographical location is also discussed, whether in dry atmosphere, exposed to bright sunlight, to an atmosphere contaminated by the fumes from industrial plants or by salt from ocean spray. A discussion of climatology is included which brings out the effect of sun, rain, condensation or dew, relative humidity, and cycling of humidity and temperature. The author attempts to show the influence of these various factors upon the probable results of outdoor exposure testing as an explanation for the many conditions imposed in ASTM tests of this nature.

Accelerated Weathering Devices. Roscoe H. Sawyer, Devoe and Raynolds Co.

Various standing committees of the Society have been interested for years in accelerating the changes produced by exposure of materials to weather. The work of these committees has been surveyed and summarized. By far the greatest amount of work has been done on paints, protective coatings, and other organic materials subject to extensive weathering change. Rather elaborate mechanical accelerated weathering devices for these materials have been developed and are in broad use. Careful evaluation of the work of these machines shows them to be controlled weathering devices giving results in a short time but not necessarily comparable with results from actual exterior exposure.

Tuesday, June 24 12:15 p.m. Tenth Session

Luncheon Session—President's Address, Recognition of American and Foreign Delegates, Addresses by Dr. R. E. Zimmerman and M. Albert Caquot, Recognition and Awards

The President's Luncheon, an Official Session of the Society, again will be an interesting occasion. This year, with the 50th Anniversary, it will provide an opportunity to recognize the official delegates of the many American and foreign societies and organizations represented at the meeting. Dr. R. E. Zimmerman, Vice-President, United States Steel Co., will present a short address on behalf of the American organizations and the response will be by the French technical leader, M. Albert Caquot, President, International Standards Organization and internationally famous engineer. It is planned that certain awards will be made and long-time members recognized. This Luncheon will be held in Hotel Statler.

Ladies are invited to this session.

Tickets can be procured in advance, or at the meeting.

Tuesday, June 24 3:00 p.m. Special Session

Standards and Research—Joint Session Sponsored by ASTM and Conference of Executives of Organization Members, American Standards Association

Informal short discussions on significant aspects of standardization and research in materials by President T. S. Fuller, Senior Vice-President H. L. Maxwell, Vice-President L. C. Beard, Jr., Vice-Presidential Nominee N. L. Mochel, Past-President Townsend, and Assistant Executive Secretary R. E. Hess. Followed by informal discussion, this Conference is especially designed to acquaint other associations and anyone interested with highlights of ASTM work and its relation to other standardization moves. A short informal session.

Tuesday, June 24 2:30 p.m. Eleventh Session

Held simultaneously with the Twelfth, Thirteenth, and Fourteenth Sessions

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water *(Continued)*

Continuous Recording of Chlorine Residuals and Determination of Chlorine Demand. A. E. Griffin, Wallace & Tiernan Co.

Instrumentation in the recording of chlorine residuals has developed slowly from the photoelectric-cell stage to the present amperometric instrument. The development of the amperometric titrator in 1942 paved the way for the present chlorine residual recorder. The equipment will record either total chlorine residual or chloramine residuals. The continuous recording of chlorine residuals has been of great benefit in detecting flaws in operational procedures and has made possible the production of a uniform product. An offshoot of the amperometric method embodies the use of the oxidation-reduction-potential principle. This system is particularly well adapted to the chlorine treatment of wastes containing cyanides where the oxidizing potential increases rapidly when sufficient chlorine has been added to complete the reactions. Continuous chlorine-demand recording equipment is in the pilot plant stage.

Measurement of Color, Turbidity, Hardness, and Silica in Industrial Waters. F. C. Staats, Hercules Powder Co.

The quality of water is of daily concern to most chemical companies because product quality is often dependent on water quality. Continuous analysis should permit realization of the close control needed.

Accepted laboratory methods for measuring color, turbidity, hardness, and silica in industrial waters are reviewed with particular emphasis on those which offer greatest promise for continuous analysis application. Standards for color and turbidity are also discussed.

Continuous Measurement of Dissolved Gases in Water. J. K. Rummel, Sheppard T. Powell.

The continuous measurement of dissolved gases in water is discussed with special regard to selection of a method, the general methods which are available, and the application of these methods to specific gases and conditions. Reference is made to the continuous measurement of dissolved oxygen, hydrogen, sulfur gases, methane, chlorine, and other gases found in water. It is observed that a practical continuous recording apparatus has not been developed for all of the applicable methods which are mentioned.

Tuesday, June 24 2:30 p.m. Twelfth Session

Held simultaneously with the Eleventh, Thirteenth, and Fourteenth Sessions

Fatigue *(Continued)*

Effect of Prior Repeated Stressing on the Fatigue Life of 75S-T Aluminum. T. J. Dolan and H. F. Brown, University of Illinois.

The damage produced in 75S-T aluminum alloy by repeated loading at one stress amplitude was measured by the relative reduction of fatigue life when the specimen was retested at a different stress level. By averaging the performance of a number of like specimens subjected to the same test conditions, the trends of the data indicated that the proportionate damage was greater than the cycle-ratio of prestressing when retested at a lower test stress, but was less than the cycle-ratio when retested at a higher test stress. For specimens subjected to a "coaxing" treatment, complete fracture of the specimens resulted after a stress history involving a relatively low cycle-ratio.

An Investigation of the Coaxing Effect in Fatigue of Metals. G. M. Sinclair, University of Illinois.

The fatigue resistance of some metals may be improved by understressing followed by a process of gradually increasing the amplitude of the alternating stress in small increments, a procedure ordinarily called "coaxing." In the present paper a study is made of the effect of various coaxing procedures on the fatigue resistance of ingot iron, SAE 1045 and 2340 steels, 75S-T6 aluminum alloy and annealed 70–30 brass. The results of this study seem to indicate that the coaxing effect in fatigue is governed by a time-dependent localized strengthening through strain-aging and not by the ability of the metal to be strengthened by cold work.

The Anisotropy of the Fatigue Properties of SAE 4340 Steel Forgings. J. T. Ranson, E. I. du Pont de Nemours and Co., and R. F. Mehl, Carnegie Institute of Technology.

The anisotropy of fatigue properties was studied statistically in SAE 4340 gun tubes using heats which showed both high and low transverse average tensile reduction of area (RAT). The average transverse endurance limit was found to be 84 per cent of the average longitudinal endurance limit in the high RAT steel, while the ratio was only 68 per cent in the low RAT steel. Life to failure at the higher stresses was similarly anisotropic with a similar dependence on quality as judged by RAT. It was concluded that the anisotropy of fatigue properties, like the anisotropy in reduction of area, is determined in a large part by the presence of fragmented stringer-type inclusions.

Fatigue Strength of "Refractaloy-26" as Affected by Temperature, Hardness, and Grain Size. F. C. Hull and P. R. Toolin, Westinghouse Electric Corp.

Refractaloy-26 is a wrought nickel-cobalt-chromium-iron base austenitic alloy, precipitation hardened with molybdenum and titanium. This paper deals with the effect on the fatigue strength of four variations in hardener content, four different solution treatments, and of several aging treatments. At 1200 F these variations result in one-hundred-million-cycle fatigue strengths from 53,000 to 85,000 psi.

In order to permit an evaluation of the effect of test temperature upon the fatigue strength, some *S-N* diagrams are also reported at 1350 and 1500 F.

A Study of Fatigue of Steels Due to Repeated Applications of Mechanical Stresses in the Finite Region of the S-N Curves. Walter G. Finch, The Johns Hopkins University.

This paper summarizes a study made of one chromium-molybdenum-vanadium and two chromium-nickel-molybdenum-vanadium steels in repeated bending in order to define the shape and level of the finite region of the *S-N* curves between the yield and endurance strengths as affected by a number of factors, such as notches, impact resistance, and tensile and yield strengths. Various types of notches were studied in order to obtain various degrees of stress concentration, namely small radius, square shoulder, 90 deg V-notch, and 45 deg V-notch. A discussion is also presented of the effect of notches on the curves for effective stress concentration factors and stress reversals, *k-N*.

(Continued in Nineteenth Session)

Tuesday, June 24 2:30 p.m. Thirteenth Session

Held simultaneously with the Eleventh, Twelfth, and Fourteenth Sessions

Symposium on Application of the Electron Microscope to Metallurgy

Pre-Shadowed Replicas for Electron Metallography. William L. Grube, General Motors Corp.

Using modifications of the Kaye-Peck technique for preparing replicas of organic fiber surfaces, direct-stripped, pre-shadowed replicas of metallographic surfaces can be made without destroying the specimen or otherwise damaging the prepared surface. Replicas may be either plastic or all metal. Pre-shadowed replicas exhibit more faithful reproduction of fine detail. Replica structure and strain marks are absent.

Electron Microstructure of Bainite in Steel. Second Progress Report by Subcommittee XI of ASTM Committee E-4, D. M. Teague, Chrysler Corp.

The results obtained from the electron metallographic examination of bainitic structures in eutectoid carbon steel indicate that the majority of the carbides found in lower bainite are extremely small, plate-like particles arranged in parallel array within long, narrow ferrite needles. The small carbide platelets appear as cross-striations at an angle of 55 deg to the ferrite needle axis.

The transition from lower to upper bainite is characterized by two distinct changes in the microstructure. The size, shape, and orientation of the carbide particles change from the cross-striated needles to larger carbide particles and stringers arranged in more nearly parallel array.

Electron-Diffraction Study of Iron Carbides in Bainite and Tempered Martensite. A. E. Austin and C. M. Schwartz, Battelle Memorial Institute.

Samples of bainite and tempered martensite, etched to leave the carbide phases in

relief, have been examined by electron diffraction. The specimens were those used in the electron microscope study of steel by Subcommittee XI of ASTM Committee E-4 on Metallography. The steel was essentially plain carbon, of eutectoid composition. Cementite was found in samples isothermally transformed or quenched and tempered at or above 500 F. Both cementite and epsilon iron carbide exist at 500 F. In martensite tempered at 400 F, only epsilon iron carbide was found.

Quantitative Metallography with the Electron Microscope. Part II. Lineal Analysis. Alfred L. Ellis, International Harvester Co.

The lineal method provides useful information regarding: (1) average particle size, (2) distance between particles, and (3) volume relationships.

This information can be obtained in a single determination. Average size and distance between particles is comparative rather than absolute. The usefulness of this information and details of the method will be discussed.

An Electron Microscope Study of the Development of Fatigue Failure. W. J. Craig, Sandia Corp., formerly with University of Illinois.

In the use of the electron microscope in metallography, an increase in resolving power is realized over the optical microscope. In this paper a pictorial comparison is made of deformation marks on the surface of alpha brass, ingot iron, and aluminum under both static and repeated loading. It is shown that under static loading the deformation is a general process taking place in all crystals while under conditions of repeated loading, the deformation is an extremely localized phenomenon taking place in a few crystals or portions of crystals.

The appearance of the individual deformation marks produced by static loading as compared with those developed by repeated loading differed with the type of metal: (*a*) in alpha brass no differences were observed; (*b*) in ingot iron slight differences were observed; (*c*) in aluminum marked differences were observed.

Report of Committee E-4 on Metallography. L. L. Wyman, Chairman.

Tuesday, June 24 2:30 p.m. Fourteenth Session

Held simultaneously with the Eleventh, Twelfth, and Thirteenth Sessions

Paint

During the 50th Anniversary Meeting of the Society, ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Materials will have special exercises commemorating its own fiftieth anniversary, for it was established in 1902, the year in which ASTM was formally incorporated.

The Committee plans a session that should be of interest to everyone concerned with the field covered by Committee D-1. Each major subcommittee concerned with materials and tests will submit a condensed paper or report giving an outline of background history and an idea of major accomplishments, but will particularly stress unsolved problems, and a prediction, if at all feasible, about things to come. All these reports will be incorporated in a published volume covering this session. The following seven of these reports will be presented.

Paint, Varnish, Lacquer and Related Products. E. W. Boughton, R. T. Vanderbilt Co., and E. H. Rose, National Lead Co.

Accelerated Tests for Protective Coatings. R. H. Sawyer, Devoe and Raynolds Co., Inc.

Varnish. J. C. Weaver, The Sherwin-Williams Co.

Exterior Exposure Testing on Wood. W. G. Vannoy, E. I. du Pont de Nemours and Co.

Physical Properties of Material. M. R. Euverard, Interchemical Corp.

Cellulosic Coatings, Related Materials. F. H. Lang, The Sherwin-Williams Co.

Painting of Metals. A. J. Eickhoff, National Lead Co.

Tuesday, June 24 5:00 p.m. Fifteenth Session

Report Session

Report of A-1 on Steel. N. L. Mochel, Chairman.

Report of A-2 on Wrought Iron. A. D. Morris, Chairman.

Report of A-6 on Magnetic Properties. R. L. Sanford, Chairman.

Report of A-7 on Malleable-Iron Castings. W. A. Kennedy, Chairman.

Report of A-9 on Ferro-Alloys. W. C. Bowden, Jr., Chairman.

Report of Joint Committee on Effect of Temperature on the Properties of Metals. Ernest L. Robinson, Chairman.

Report of C-13 on Concrete Pipe. W. W. Horner, Chairman.

Report of D-7 on Wood. L. J. Markwardt, Chairman.

Report of E-2 on Emission Spectroscopy. B. F. Scribner, Chairman.

Report of E-3 on Chemical Analysis of Metals. J. W. Stillman, Chairman.

Report of Committee E-7 on Non-Destructive Testing. J. H. Bly, Chairman.

Wednesday, June 25 9:30 a.m. Sixteenth Session

Held simultaneously with the Seventeenth, Eighteenth, and Nineteenth Sessions

Symposium on Light Microscopy

Report of Committee E-1 on Methods of Testing. J. R. Townsend, Chairman.

Symposium on Light Microscopy

The Methods of Microscopy. C. W. Mason, Cornell University.

Technical microscopy involves more than apparatus and preparative techniques; it necessitates an extension of reasoning in terms of small-scale structures and processes. Such visualization contributes to nonmicroscopical as well as to microscopical testing and study of materials; ignoring microstructural factors seriously restricts sound progress. Standardization of methods may be overemphasized; intelligent formulation of key experiments requires flexibility of procedures and thinking.

Apparatus for Microscopy. H. W. Zieler, W. H. Kessel and Co.

In the first section the paper describes the main types of microscopes and auxiliary devices (illumination apparatus) which serve for the revelation of detail of objects having different optical characteristics such as transparent colorless and colored (bright field, dark field, and phase), opaque (vertical and indirect illumination).

In the second section the paper describes apparatus for optical analyses with a microscope such as determination of anisotropic properties in polarized light (transmitted and reflected), microphotometry, microspectometry, microrefractometry, microfluorimetry, and many other applications where the magnifying process is incidental to the determination of optical properties.

Some Applications of Light Microscopy in the Study of Textile Materials. Verne W. Tripp, Southern Regional Research Laboratory, U. S. Department of Agriculture.

A brief discussion of the use of the light microscope in the evaluation of textile materials is given. The scope, methods, and techniques of textile microscopy are outlined, with emphasis on those which form the basis of present-day testing and control work. The smaller microtomes are rapid and efficient for fiber and most yarn work; the rotary microtome is well adapted to fabric sectioning. The use of the techniques discussed in studies of textile processing and behavior is described and illustrated.

Polarized Light Microscopy of Crystals. W. C. McCrone, Armour Research Foundation.

The methods of polarized light microscopy as applied to the study of crystals will be illustrated and discussed. Particular attention will be paid to the use of these data for the study of chemical problems using the microscope. An effort will be made also to show that simple equipment can be used in many cases where more costly microscopes and accessories are not available.

(Continued in Twentieth Session)

Wednesday, June 25 9:30 a.m. Seventeenth Session

Held simultaneously with the Sixteenth, Eighteenth, and Nineteenth Sessions

Symposium on Determination of Elastic Constants

There has been a renewed interest in methods for determining elastic constants with the rapidly increasing use of metals at elevated temperatures in engines of many types and the use of plastics and of composite materials in aircraft and other structures. In many of these cases adequate values of the elastic constants are not available in the literature and measurements must be resorted to. Various methods of measurement and their advantages and limitations are to be discussed in a symposium on determination of elastic constants under the sponsorship of Committee E-1 on Methods of Testing. The symposium consists of five papers prepared by specialists in the field. Each paper is to be followed by discussion in order to cover the field as fully as possible and to indicate which methods may be ready for standardization by ASTM.

Report on ASTM Task Group for Determination of Elastic Constants. Walter Ramberg, National Bureau of Standards.

The paper reports on returns from a questionnaire which was sent by the Task Group to 112 individuals and laboratories to determine the needs in respect to elastic constants and to ascertain present practice in the determination of elastic constants. Sixty-seven questionnaires were returned. Analysis of the returns showed that the principal desire is for values of Young's modulus for metals at elevated temperatures and for nonmetals, particularly rigid plastics and ceramics, at all temperatures below the softening temperature. Present practice in determining elastic constants appears to be concentrated on Young's modulus. Methods for determining this quantity were listed 73 times as against 18 each for Poisson's ratio and shear modulus.

Influence of Temperature on the Elastic Moduli and Poisson's Ratio of Various Commercial Steels. F. Garofalo, P. R. Malenock, and G. V. Smith, United States Steel Co.

The effect of temperature on the elastic modulus in tension (E), the shear modulus (G), and the computed Poisson's ratio 21 commercial steels, both carbon and alloyed, has been determined using a specimen of circular cross-section statically loaded in simultaneous bending and twisting.

Test results show that both E and G decrease approximately linearly with increasing temperature up to 700 or 900 F for the plain carbon or ferritic alloy steels, respectively. Beyond these temperatures a sharp drop is observed. For the austentic stainless steel G (in general) decreases approximately linearly up to 1300 F before decreasing more sharply. The tensile modulus E behaves in a similar manner for these steels with the exception of the unstabilized AISI Types 310 and 316 which show a discontinuity in the tensile modulus-temperature curve in the range of 700 to 900 F. No systematic variation in Poisson's ratio is found.

Comparison between the present results and others found in the literature, determined from static as well as dynamic measurements, indicates unusually good agreement.

Methods for Determining the Elastic Constants of Non-Metallic Materials. E. W. Kuenzi, Forest Products Laboratory.

Test methods are described for determining the elastic properties of wood, plywood, glass-fabric laminates, and a variety of sandwich-core materials. The experimental procedures were those developed over a period of years and are used extensively at the Forest Products Laboratory in connection with research on these materials. Methods representing practice that is regarded as the best at present are described in detail where necessary. Alternative methods and their disadvantages are discussed briefly.

Dynamic Methods for Determining Elastic Constants and Their Temperature Variation in Metals. M. E. Fine, Bell Telephone Laboratories, Inc.

In dynamic measurement of elastic constants, the specimen is part of a vibrating system. An introduction to the theory is given, and the various methods (ranging in frequency from a fraction of cycle to 30 megacycles per second) are critically reviewed. Dynamic methods are capable of giving precise results and are more convenient than static measurements if the sample is small, brittle, has large creep effects, or knowledge of the elastic constants as functions of temperature is desired. Furthermore internal friction may usually be measured in the same apparatus. Besides giving engineering information, dynamic elastic measurements have proved valuable for investigating phenomena in metals.

An Evaluation of Several Static and Dynamic Methods for Determining Elastic Moduli. J. T. Richards, The Beryllium Corp.

Available static and dynamic test methods are surveyed for determining elastic moduli in tension, compression, flexure, shear, and torsion. Consideration is given to influencing factors including testing speed, stress level, accuracy, specimen size and shape, temperature, pressure, and prior history. As a means of evaluation, specimens from several lots of beryllium-copper rod were submitted to various laboratories for test by various procedures and the results compared. An explanation of the differences on the basis of test methods and conditions is attempted.

Rheotropic Embrittlement. E. J. Ripling, Case Institute of Technology.

The ductility deficiency exhibited by metals not crystallizing in the face-centered cubic system, when these metals are strained at low temperatures, high strain rates, or in the presence of hydrostatic tension, has recently been shown to be partially strain curable. The portion of this embrittlement which can be overcome by prestrain under some ductile conditions has been labeled "rheotropic embrittlement."

Descriptions of several of the variables which influence rheotropic behaviors have been presented in a number of publications. This paper is a correlated abstract of the influence of these variables.

Wednesday, June 25 9:30 a.m. Eighteenth Session

Held simultaneously with the Sixteenth, Seventeenth, and Nineteenth Sessions

Symposium on Fretting Corrosion

The phenomen of fretting corrosion has been recognized for over two decades but a partial understanding of its mechanism has been arrived at only in recent years. The study of fretting corrosion has necessarily included lubrication studies. Lubricating greases are widely used as lubricants in anti-friction bearings and Technical Committee G on Lubricating grease of Committee D-2 on Petroleum Products and Lubricants has a corresponding interest in fretting corrosion which prompted them to sponsor the symposium.

NACA Research on Fretting. Douglas Godfrey, National Advisory Committee on Aeronautics.

The purpose of the NACA research on fretting is to determine the basic mechanism and investigate principles of mitigation. Technical film 23, which will be presented, illustrates the approach to the problem. Views of susceptible surfaces in a jet engine and of fretted bearings as well as color motion photomicrographs of fretting action between steel and glass and ruby and glass will be shown. The research indicated that fretting is initiated and propagated by loosening, due to inherent adhesive forces, of finely divided and apparently virgin material, that is extruded from the contact area and reacts with oxygen simultaneously. Generally, fretting may be considered a form of concentrated and severe wear.

The Present Status of Fretting Wear. W. E. Campbell, Bell Telephone Laboratories, Inc.

A general discussion of fretting wear of metal surfaces is presented. It is concluded that the phenomenon is not corrosion in the usual sense, but wear due to oscillatory relative motion of sufficiently high amplitude to cause gross slip between the contacting surfaces, accelerated in certain cases by abrasive oxide films formed as a result of the wear.

The only measure which eliminates wear entirely is the elimination of gross slip between the metal surfaces. This can be done by reducing the amplitude of the oscillatory motion or by interposing between the surfaces a material of high enough shear elasticity to prevent gross relative motion.

Other methods of mitigating fretting are discussed and suggestions for future research on the mechanism are given.

Fretting Corrosion Tendencies of Several Combinations of Materials. J. R. McDowell, Westinghouse Electric Corp.

A large number of combinations of materials, both metallic and nonmetallic, were subjected to conditions producing fretting corrosion in an effort to evaluate their comparative susceptibility to this action. A table is given listing the results into three groups of relative resistance. Observations were also made to determine qualitatively the effect of such variables as velocity of slip, pressure between surfaces, amount of slip, and surface finish.

All rigid materials were found either to corrode with oxide debris or to be affected by a fretting action which roughened the surface. Two contradictions to published data were found in that magnesium on cast iron is a poor combination and that surface roughness has little effect. Some nonmetallic materials are worse than metals. Dry lubricants only delay the action while rubber

cement by excluding air prevented corrosion during the test life. A rubber gasket completely stopped the corrosive action.

Fretting Corrosion in Fitted Members. O. J. Horger, The Timken Roller Bearing Co.

Design members incorporating clamped, press or shrink fitted assemblies which are subjected to vibratory stresses develop fretting between the mating surfaces. Serious problems of wear and a reduction in fatigue strength result from this fretting action.

This subject is discussed principally from its influence on fatigue resistance of shafts 7 in. in diameter and over from observations in both the laboratory and field service. Fretting action leads to the initiation of fatigue cracks at a very low order of fluctuating stress which stress is often within good design limits from other considerations.

Very definite limitations from a practical standpoint occur in attempting to stop these fatigue cracks from initiating. The time and stress required for the propagation of these cracks to a dangerous depth which requires replacement of parts may be tremendously increased.

(Continued in Twenty-first Session)

Wednesday, June 25 9:30 a.m. Nineteenth Session

Held simultaneously with the Sixteenth, Seventeenth, and Eighteenth Sessions

Fatigue *(Continued)*

Report of Committee E-9 on Fatigue. R. E. Peterson, Chairman.

Plastic-Flow and Work-Hardening Phenomena in Fixed-Deflection Fatigue Tests of Magnesium Alloys. E. H. Schuette, The Dow Chemical Co.

Whenever fatigue tests are conducted in fixed-deflection machines at stresses above that for which the load-displacement relationship is essentially elastic, the possibility exists that the load on the specimen will change during the course of the test. It is possible to introduce substantial errors in this manner. The phenomena involved have been investigated for several magnesium alloys, for both axial-load and repeated-flexure testing, and recommendations are made for testing procedures designed to minimize the undesirable effects.

Fatigue of 76S-T61 Aluminum Alloy Under Combined Bending and Torsion. W. N. Findley, University of Illinois.

Fatigue data for 76S-T61 aluminum alloy are presented for several combinations of bending and torsion. The special fatigue equipment for these tests is described. Fatigue data in torsion are presented for two different type fatigue machines and results of static tests are tabulated.

The literature on the effect of combined stress in fatigue is reviewed and the results of the present series are compared with various theories. A new notation for state of stress and a new criterion for combined stress results is described. A possible correction for anisotropy and energy theories of fatigue under combined stress is discussed.

Fatigue Machines for Low Temperatures and for Miniature Specimens. W. N. Findley, University of Illinois, W. I. Mitchell, Iowa State College, and R. L. Sutherland, University of Iowa.

The design and features of the following new types of fatigue testing apparatus are described:

a. A high-speed rotating-beam fatigue machine designed for operation at temperatures as low as −320 F. This machine employs a vertical spindle and has a device for adjusting the alignment of the specimen.

b. A repeated-bending fatigue machine for tests at temperatures as low as −320 F. This machine was equipped with a device to permit tests in bending, torsion, or combined bending and torsion. Various mean stresses may also be employed.

c. A repeated-bending fatigue machine equipped with suitable fixtures to permit tests of miniature specimens ¾ in. long in either bending or torsion.

Effect of Tensile and Compressive Fatigue Stress on Creep, Rupture, and Ductility Properties of Temperature Resistant Materials. B. J. Lazan, University of Minnesota, and E. Westberg, Syracuse University.

Newly developed grips and machine improvements are described for fatigue loading under direct stress (tension-compression) ratios of alternating to mean stress from zero to infinity. Dynamic creep, rupture, and ductility data are reported on N-155, S-590, and Vitallium at 1350 and 1500 F under direct stress combinations from static to reversed loading. Stress range diagrams (alternating stress *versus* mean stress) are presented to indicate the stress combination which will produce rupture and various degrees of creep in 5 to 1500 hr. Data on total per cent elongation and elongation to start of third stage of creep are presented and analyzed in terms of alternating-to-mean stress ratio and stress magnitude.

Dynamic Testing of Materials and Structures with a New Resonance Vibration Exciter and Controller. B. J. Lazan, A. Gannett, P. Kirmser, J. Klumpp, University of Minnesota, and J. Brown, Syracuse University.

A newly developed machine is described for exciting and controlling resonance or near resonance vibrations in materials and joints under various types of stress. This machine imposes an adjustable-while-running mechanical exciting force at a controllable frequency and by means of automatic electronic controls maintains the desired vibration phase angle and the desired magnitude of the excited force. Data are presented on the damping and elasticity properties of aluminum and mild steel, and these are compared with results procured in rotating cantilever beam equipment. The resonance response, damping, and elasticity properties of a bolted joint were determined and the effects of bolt tension and molybdenum disulfide lubrication are illustrated and partially analyzed.

Wednesday, June 25 2:00 p.m. Twentieth Session

Held simultaneously with the Twenty-first and Twenty-second Sessions

Symposium on Light Microscopy *(Continued)*

Applications of Light Microscopy in Concrete Research. Katharine Mather, Waterways Experiment Station.

The applications of light microscopy in concrete research are outgrowths of its applications in petrology, mineralogy, and chemistry, but there is more quantitative emphasis than is common in petrology. Metallographic and combined petrographic and metallographic techniques are used to study portland cement. Normal petrographic methods are used to study aggregates. Air content and bubble spacing in concrete are investigated by linear traverse and point-count techniques. The use of light microscopy in making comparative studies of the microstructure of concrete is described.

The Microscopic Examination of Metallic Specimens. J. R. Vilella, United States Steel Co.

Before a metallic specimen is examined microscopically it is generally polished to a mirror finish and etched with a suitable reagent. The dependence of the appearance of the structure of a metallic specimen on the technique of polishing and etching is discussed and illustrated, with particular emphasis on the modifications of the appearance of the structure resulting from distortion of the surface metal during polishing. The use in metallography of oblique illumination, polarized light, dark field illumination, phase contrast, and ultraviolet light is discussed and illustrated.

Microscopy of Resins and Plastics. T. G. Rochow, American Cyanamid Co.

Testing resinous materials is generally to correlate practical values with variations in manufacture. If correlation is unapparent or unreasonable, the situation requires vision, both physiological and mental. The microscope is necessary or helpful for several reasons: (1) Emulsified or suspended resins contain particles of microscopic sizes. (2) Consolidated resins are characteristically structureless to the unaided eye, but may contain microscopic particles. (3) Many resinous plastics, paints, etc. contain non-resinous particles of microscopic sizes, in random or designed arrangement. (4) Microscopists can give wide variety of scientific information: statistical, physical, chemical, geological, and biological. (5) Microscopical information can be interpreted to control quality and to experiment in improvements.

Micrographs will be shown as examples.

Particle Size. R. P. Loveland, Eastman Kodak Co.

Wednesday, June 25 2:00 p.m. Twenty-first Session

Held simultaneously with the Twentieth and Twenty-second Sessions

Symposium on Fretting Corrosion *(Continued)*

Effect of Lubricants in Minimizing Fretting Corrosion. E. W. Herbek, The Texas Company, and R. F. Strohecker, Air-Research Manufacturing Co.

The principal theories on the mechanism of fretting corrosion are briefly reviewed. A literature survey of numerous studies on the effect of lubricants on fretting is presented, bringing out that investigators differ on the corrective effects of specific lubricants. Fretting corrosion data obtained on various greases (using a modified version of the Fafnir Friction-Oxidation Tester) are presented. It is concluded that feedability is of prime importance in minimizing fretting and that specific soap bases, solid materials such as ZnO or MoS_2, and additives such as tricresyl phosphate do not, *per se*, alleviate fretting.

The Mechanism of Fretting Corrosion. H. H. Uhlig, Massachusetts Institute of Technology.

Quantitative data on fretting corrosion have been obtained under carefully controlled experimental conditions. Load on the fretted surface, total slip, frequency of vibration, and composition of the atmosphere were independent variables in a series of measurements on 1018 steel employing a test machine of new design. Data obtained so far have made possible a comprehensive theory of fretting corrosion which is in good agreement with the facts. The test machine and data are described together with a survey of the literature on the proposed basic mechanisms that operate in this type of damage.

Wednesday, June 25 2:00 p.m. Twenty-second Session

Held simultaneously with the Twentieth and Twenty-first Sessions

Non-Ferrous Metals

The Creep Properties of Sand Cast Aluminum Materials 319-T71, 319-F and 356-T7. John E. Dorn and O. D. Sherby, University of California.

The creep and stress-rupture properties of 319-T71, 319-F, and 356-T7 sand-cast aluminum-alloy materials were determined over the range of temperatures from 90 to 400 F and times under stress up to 1000 hr.

The order of decreasing creep resistance is given as follows: at 90 F—319-T71, 319-F, 356-T7; at 400 F—319-F, 319-T71, 356-T7.

The inversion in the order of creep properties with increasing temperatures between the two tempers of sand-cast alloy 319 is probably ascribable to the difference in stability of the microstructure of the two materials as a function of temperature.

Plastic Stress-Strain Relations for Biaxial Tension and Variable Stress Ratios. Joseph Marin and L. W. Hu, The Pennsylvania State College.

The main objective in this investigation was to determine the validity of the plasticity theories and the correctness of the assumptions made in these theories. For this purpose, plastic stress-strain relations for biaxial tensile stresses were determined for a 14S-T4 aluminum alloy. The biaxial tensile stresses were produced by subjecting a thin-walled tubular specimen to axial tension and internal pressure.

In one type of test, a stress was applied in the axial direction of the tube to a selected plastic strain value, and the stress was then applied in the lateral direction.

A second type of special tests consisted in first applying a stress in the axial direction of the tubular specimen, removing this stress and then applying a stress in the perpendicular lateral direction.

A third kind of special tests consisted in first applying the lateral stress to some value and then the axial stress in increments.

Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought. G. H. Harnden, Chairman.

Appendix:

Effect of Speed of Testing on the Tensile Properties of Copper and Copper-Base Alloys. N. H. Murdza, Frankford Arsenal.

This paper presents the results of a series of round-robin tension tests on copper and copper-base alloys sponsored by Subcommittee G-1 of ASTM Committee B-5 on Copper and Copper Alloys Cast and Wrought to determine the effect of testing speed on the tensile properties. The tests were made by various Government (both United States and Canadian) and industrial testing laboratories throughout the country. The data presented in this paper show the effect of speed on the yield strength, tensile strength, and elongation of copper and free-cutting brass rod.

Restoration of Ductility of Cold-Worked Aluminum, Copper, and Low-Carbon Steel by Mechanical Treatment. N. H. Polakowski, University College of Swansea.

It is shown that the ductility of certain work-hardened metals is rapidly, and sometimes substantially improved by mechanical treatment inducing large cyclic deformations. Reversed bending was found best for this purpose thus indicating that the mechanical properties of cold-rolled sheet or drawn bars may be modified by controlled processing in roller levelers and similar equipment. An analysis of background evidence and own results is given, based upon a pure stress concept. This suggests that softening of work-hardened aluminum and copper under cyclic strain may account for the insignificant effect of cold working on fatigue strength x of these metals.

Load Deflection Relationships in Slow-Bend Tests of Charpy V-Notch Specimens. Richard Raring, Naval Research Laboratory.

Load-deflection diagrams of slow-bend tests, at temperatures through the transition range of Charpy V-notch specimens of quenched and tempered and of pearlitic steels representing a carbon range of 0.01 to 0.63 per cent and a tensile strength range of 48,000 to 152,000 psi are shown. Characteristics of the diagrams and of the development of the crack are observed. Results are compared, on the basis of energy absorbed and of transition temperature, with those of impact tests of the same steels. Some correlation between the slow notch-bend tests and tension tests is shown.

Effects of Machining Specimens on the Results of Tension Tests of Annealed Aluminum Alloys. G. W. Stickley and K. O. Bogardus, Aluminum Research Laboratories.

The machining of specimens for mechanical tests of metals produces some cold work adjacent to the prepared surfaces. Generally its effects are insignificant. Tests described in this paper, however, show that for annealed pure aluminum and aluminum alloys having yield strengths less than 10,000 psi there may be important effects upon the values obtained for yield strength and, to a lesser extent, for elongation. The effect may vary also with type and size of specimen. The only way of eliminating these effects is by testing full size or by testing specimens machined before annealing.

An Inquiry into the Reproducibility of Impact Test Results. Humphrey L. Fry, Bethlehem Steel Co.

This paper presents results of an extensive investigation showing that supposedly accurate, properly calibrated impact testing machines may give widely divergent results on the same material. The results indicate the difficulty or perhaps impossibility of standardizing the test in its present form. Both Charpy and Izod tests are included in the investigation.

Consideration is given to possible causes of the discrepancies between machines and an investigation of one possible cause by means of high-speed motion pictures is described.

It is pointed out that because two laboratories cannot be certain of reproducing each other's results, the impact test is not suitable for specifying material.

Wednesday, June 25 4:00 p.m. Twenty-third Session

Marburg Lecture, Dudley Medal, and Awards

Marburg Lecture—Non-Destructive Testing. R. C. McMaster, Battelle Memorial Institute.

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasizing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society, who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials.

Charles B. Dudley Medal

Richard L. Templin Award

Recognitions

Wednesday, June 25

50th Anniversary Dinner 7:00 p.m.

Preceded by Cocktail Party 5:30 p.m.

Guest Speaker, Detlev W. Bronk, President, National Academy of Sciences, and also President, The Johns Hopkins University

The New York Committee on Arrangements is acting as the official host for the Anniversary Meeting. It has arranged an informal dinner preceded by a cocktail party for Wednesday evening, June 25 at the New Yorker. The Cocktail Party is being complemented to all those purchasing tickets for the informal dinner. The dinner will feature a talk by Dr. Bronk which will be of interest to all of our members and their families.

After dinner the Committee has arranged for dancing and entertainment in the Main Ballroom, to which all members are invited. A form for dinner reservations will be mailed to members late in May.

Symposium on Non-Destructive Materials—Thursday, June 26—9:30 a.m., 2 p.m., and 8 p.m.

Committee E-7 has planned technical sessions on nondestructing testing with an international atmosphere. Foreign authors will present papers on various types of nondestructive tests as conducted in their respective countries. Following each paper it is planned to have a designated American specialist compare the American technique with the European practice. It is proposed to include contributions from the following:

Dr. Werner Felix, Switzerland—on Ultrasonic Non-Destructive Testing.

Dr. Frederick Forster, Germany—on Magnetic Non-Destructive Tests.

Dr. Paul Bastien, France—on Ultrasonics.

Dr. Oscar Masi, Italy—on Radiography of Welds.

Dr. den Hartog, Holland—on Comparisons of Non-Destructive Test Methods Used in Examining a Damaged Stern-Post.

Myron Falk, England—on Gamma-Radiography Practices in Great Britain.

Hans Vinter, Denmark—on Field X-Ray Techniques Used in Demark.

William C. Hitt, U.S.A.—on Immersed Ultrasonic Non-Destructive Testing.

Thursday, June 26 9:30 a.m. Twenty-fourth Session

Held simultaneously with the Twenty-fifth and Twenty-sixth Sessions

Symposium on Testing Adhesives for Durability and Permanence

Report of Committee D-14 on Adhesives. Frank W. Reinhart, Chairman.

Symposium on Testing Adhesives for Durability and Permanence

One of the most important questions arising when fabrication with an adhesive is being considered is the durability of permanence of the adhesive, or how long the joint will last and how the joint will stand up in service. Many of the adhesives now being used have been developed within the past ten years, and consequently lack the background of many years of service typical of other materials of construction. Thus accelerated permanence tests are of much importance and it is desirable to review in this Symposium, in the light of field experience, some of the tests that have been used. It is hoped correlation of field data and laboratory test data will eventually result in improved test methods for permanence in Committee D-14 on Adhesives.

The Effect of Specimen Structure in Permanence Tests on Wood Adhesives. Robert P. Hopkins, Rohm & Haas Co.

This paper is concerned with the significance of construction (including wood species) of the test specimen on the apparent durability of synthetic resinous wood adhesives. It therefore emphasizes mechanical stress variation as a factor to be distinguished from chemical factors in evaluating the permanence of an adhesive. Data are provided on both outdoor exposure and laboratory cyclic tests to demonstrate that variations in respective results are partially attributable to variations in the mechanical stressing of the glue.

Glass Adhesives. Frank Moser, Pittsburgh Plate Glass Co.

Adhesives for glass surfaces are classified according to chemical type. The more promising ones for bonding glass are the modified phenolics, the butadiene acrylonitrile vinyl copolymer, and butadiene acrylonitrile polyvinyl butyral. Vinyl phenol, polyvinyl acetate, the celluloses, acrylates, rubber latex, and cyclo-rubber types give fair adhesion for room temperature exposure, but deteriorate quite rapidly under moist conditions. Glass-metal adhesives require good weathering qualitities, but also must be tested for temperature cycling in order to eliminate the more brittle types which induce strains which are responsible for glass failure due to differences in thermal expansion. Thus, a well-rounded testing program is very beneficial in selecting adhesives for respective fabrications.

Current Investigations of the Durability of Woodworking Adhesives. Richard F. Blomquist, Forest Products Laboratory.

Factors contributing to the failure of bonded-wood joints in service are discussed. Various exposure tests that have been, or are being used, to evaluate the durability of different woodworking adhesives are described and their advantages and limitations are considered. Special problems discussed include those in the use of adhesives in plywood, laminated timbers, prefabricated housing, and in furniture. Consideration is also given to the problems of developing suitable accelerated test procedures for evaluation of the durability of adhesives for wood.

Determination of Mechanical Properties and Deterioration of Adhesives. Albert G. H. Dietz, Herman N. Bockstruck, and George Epstein, Massachusetts Institute of Technology.

An ultrasonic nondestructive method for testing adhesive joints has been used to study deterioration of phenolformaldehyde polyvinylbutyral adhesive bonds. The specimens were composed of two cylindrical metal bars cemented end-to-end. Two metals, stainless steel and 24ST aluminum, which have different coefficients of thermal expansion, have been utilized.

The cemented specimens have been subjected to various heat and cold treatments. No deterioration has been observed as a result of the low-temperature treatments, but certain high temperatures, dependent upon the specimen metal and diameter, do cause deterioration. The results indicated by the ultrasonic tests have been confirmed by actual tension tests.

The same ultrasonic equipment, with a few minor changes in the mechanical features of the specimen mount system, has also been used to measure the dynamic modulus of the rubbery polysulfide type adhesives. Capacitance measurements have also been made on polysulfide bonds.

Field and Laboratory Tests for Durability and Permanence: Adhesives Belonging to the Rubber-Resins System. John F. Anderson and L. F. Fiedler, The B. F. Goodrich Co.

This paper concerns itself with a limited field of adhesives which have come into use for such purposes as bonding friction materials to metals (for example, brake bonding); metal to metal (for example, secondary structures in automotive and aeronautical industries). These materials are discussed from these angles: (1) relationship to other types of joining, (2) relationships to other adhesives, (3) laboratory tests for evaluation of the adhesives and of the bonds, and (4) field tests which indicate the utility and practicability of the adhesives as engineering materials.

Durability and permanence are defined in the light of this particular class of adhesives.

Thursday, June 26   9:30 a.m.   Twenty-fifth Session

Held simultaneously with the Twenty-fourth and Twenty-sixth Sessions

Symposium on Factors Affecting the Durability of Concrete

The program of durability of concrete is directly toward some of the prominent factors which determine durability and tests for evaluating these factors. The tests cover a wide variety of conditions both in the laboratory and under severe outdoor exposures. Time intervals over which some of the tests were made carry back to the early period of development of air entrainment, and precede the recognition of alkali-aggregate reaction. These two factors, and others not so well known, are treated in the papers.

Significant Factors Affecting Concrete Durability. C. H. Scholer, Kansas State College.

A major activity of the Subcommittee on Durability of Concrete of Committee C-9 on Concrete and Concrete Aggregates was the development of an outline of all factors that might influence concrete durability. These factors were subdivided into five major groups: the character of the constituent material of which the concrete is composed; the effect of the construction processes; the physical characteristic of the hardened concrete; the nature of the natural exposure to which the concrete will be subjected; and the type of loading the structure will be called upon to carry.

Correlation of Sodium Sulfate Soundness of Coarse Aggregate with Durability and Compressive Strength of Air-Entrained Concrete. C. A. Vollick and E. I. Skillman, U. S. Bureau of Reclamation.

The sodium-sulfate soundness test of aggregate and the freezing and thawing durability test of concrete used by the Bureau of Reclamation to evaluate aggregates are briefly discussed. Coarse aggregates from 70 different sources have been tested in five cycles of sodium sulfate, and air-entrained concrete made with these aggregates has been tested for freezing and thawing durability and compressive strength. Relationships between sodium-sulfate soundness of the aggregate and freezing and thawing durability, compressive strength, and cement content of the concrete are analyzed statistically.

Experimental Exposure of Concrete to Natural Weathering in Marine Locations. H. K. Cook, Corps of Engineers, Waterways Experiment Station.

Presents a résumé of results of tests on approximately 2500 concrete specimens exposed at half-tide level in sea water. The major portion of the specimens has been exposed at Eastport, Me., and are subjected to repeated cycles of freezing and thawing in the Winter. Others are exposed at St. Augustine, Fla., where no freezing occurs. The specimens represent various concrete mixtures with and without air-entrainment and various aggregate combinations. The maximum exposure represented is 16 yr. The major number of specimens have been exposed for 12 yr.

Performance of Concrete Specimens During 10 Years Exposure to Severe Natural Weathering. W. J. McCoy and S. B. Helms, Lehigh Portland Cement.

In 1941 concrete beams prepared from gravel concrete mixes were stored outdoors, partially immersed in water. In group *A*, all five types of portland cement classified in ASTM Standard Specifications for Portland Cement (C 150) and the two types covered in ASTM Tentative Specifications for Air-Entraining Portland Cement were studied, using 4.5 and 6-sack mixtures and a 3-in. slump. In group *B*, five type I portland cements were compared and one sample was tested using an alumina powder admixture. These mixes were based on a fixed water-cement ratio and at 0, 3, and 6-in. slumps.

Sonic modulus of elasticity was measured semiannually for 6 yr and finally at 10 yr. In some cases failure of specimens was portended by cracking which impaired the utility of sonic tests. Results show better resistance for rich mixes in group *A*, the 3-in. slump concretes were superior in group *B*, and improved durability was found due to entrained air.

Studies of Abnormal Expansion of Portland Cement Concrete Containing Sand-Gravel Aggregate Common in the Central Great Plains Region of the United States. A. D. Conrow, Ash Grove Lime & Portland Cement Co.

Much deterioration of concrete containing the sand-gravel common to the Central Plains region of the United States has been observed. The deterioration is apparently due to some abnormal expansion of the concrete resulting from interaction of the cement paste and the aggregate.

An exposure was standardized which induced rapid development of an abnormal expansion believed to be similar in nature to that observed in the structures in service. The exposure was used to develop the expansion for the purposes of study and to search for means to prevent or inhibit it.

Thursday, June 26   9:30 a.m.   Twenty-sixth Session

Held simultaneously with the Twenty-fourth and Twenty-fifth Sessions

Symposium on Textiles

Report of Committee D-13 on Textile Materials. W. D. Appel, Chairman.

Symposium on Textiles

An Engineering Approach to an Understanding of the Properties and Utilization of Textile Fabrics. Walter J. Hamburger, Fabric Research Laboratories, Inc.

Status of Synthetic Textiles—Their Promise for the Near Future. An address by C. W. Bendigo, American Cyanamid Corp.

Statistical Considerations in Fiber Research. Thomas F. Evans, Textile Research Institute, Inc.

Physical or chemical tests involving single fibers can be made to yield more precise or more informative data when statistical principles are employed in their design and analysis. The discovery of the major sources of variability through analysis of variance is an important step in formulating an efficient sampling and testing procedure for any type of research program. The data required can frequently be obtained without additional experimentation. The number of fibers which will be required to differentiate between two samples can be estimated, either from a small preliminary experiment or from previous knowledge. The elimination of bias and the determination of confidence limits are further advantages to be gained from a statistical approach to research problems.

Applications of Statistics to Quality Control in the Textile Industry. Robert Jones, Bigelow-Sanford Carpet Co.

The use of the statistical techniques of the normal distribution curve in analyzing industrial data is explained with particular reference to measurements of quality characteristics such as weight, diameter, strength, and other measurable features of a process or product. Applications of probability concepts have been valuable in industrial Quality Control in comparing actual results with specifications, in setting specifications, in inspection, and in locating sources of quality difficulties. Reference is made to examples taken from the textile industry.

Thursday, June 26   2:30 p.m.   Twenty-seventh Session

Held simultaneously with the Twenty-eighth and Twenty-ninth Sessions

Symposium on Plastics Testing—Present and Future

Report of Committee D-6 on Paper and Paper Products. W. R. Willets, Chairman.

Report of Committee D-9 on Electrical Insulating Materials. A. H. Scott, Chairman.

Report of Committee D-10 on Shipping Containers. A. J. Carlson, Chairman.

Report of Committee D-20 on Plastics. G. M. Kline, Chairman.

Symposium on Plastics

The papers of this symposium have as their common purpose the critical examination of some procedures employed for determining certain physical and physical-chemical properties of plastics, comparing those now available as standard methods with some whose development to that status in the future is to be desired. The introduction of the papers by the Chairman of Committee D20 will indicate pertinent background and interrelationships.

The Measurement and Significance of the Mechanical Strength Properties of Plastics. C. Howard Adams, Monsanto Chemical Research Department.

Many types of strength tests are used to characterize plastics materials. Those that provide the most significant information, including the comparatively recent and important addition to the field, dynamic or vibrational, will be discussed. Most of today's testing is done at loading or straining

rates where instrumentation is not a problem. However, the engineering and theoretical nature of plastics is better assessed at the extremes of the testing speed scale. Data are presented illustrating this point.

Measurement of the Effect of Temperature on Some Physical Properties of Plastics. J. P. Tordella, E. I. du Pont de Nemours and Company.

Measurement of Color, Gloss and Haze. H. K. Hammond, III, National Bureau of Standards, and G. W. Ingle, Monsanto Chemical Co.

The capabilities and limitations of methods of test for color, gloss, and haze are discussed and adaptations of them are described. Published methods of test contained in the ASTM Book of Standards are: color—D 307, D 791; gloss—D 523; haze—D 672, D 1003. Some problems associated with the correlation of subjective estimates of these appearance attributes with objective measurements are discussed.

Effect of Molding Conditions on Permanence of Plastics. J. L. Williams and J. W. Mighton, The Dow Chemical Co.

During their useful life, plastic objects are subjected to a wide variety of chemical, thermal, and mechanical conditions. Predictions of their permanence properties are difficult unless consideration is given to the variations caused by the fabrication techniques and the testing methods. Data are presented showing the effect of certain fabrication procedures on the physical and permanence properties of some thermoplastic and thermoset materials. Even though there are many ASTM methods describing evaluation procedures for permanence, and outlining standard methods for fabrication of test specimens, there is a need for considerable future work.

An Improved Fadeometer. Ladislav Boor and Seymour L. Trucker, Philadelphia Quartermaster Depot, U. S. Army.

Three of the important factors which determine the qualitative and quantitative chemical changes associated with weathering are light, temperature, and moisture. In commercial machines designed to simulate outdoor weathering, these factors are not controlled to the degree of precision comparable to that of the various instruments now in use for measuring changes in such properties as reflectance and transmission.

A weathering apparatus using the Atlas-type enclosed arc as the light source has been built in which the temperature and relative humidity of the air in contact with the specimens are controlled, and are variable over a wide range of ambient conditions. The design of the apparatus and means of achieving control of these variables are described.

Prediction of Creep Curves from Stress-Strain Data. Yoh-Han Pao and Joseph Marin, The Pennsylvania State College.

This paper develops a method for predicting tension creep-time relations for constant stresses from tension stress-strain relations at various strain rates. The method is applied to test data obtained using plexiglas and the agreement between actual and predicted creep-time curves was found to be good. The proposed procedure given in this paper differs from other "equations of state" procedures in considering the creep strains and creep rates and not the total strains and total strain rates when using the stress-strain relations for predicting the creep-time curves. This is equivalent to suggesting that a mechanical equation of state exists for creep strains and creep rates alone.

Residual Stresses in Compositions of Phenolic Resins. H. M. Quackenbos, Jr., Bakelite Co., Division of Union Carbide and Carbon Corp.

Thursday, June 26 2:30 p.m. Twenty-eighth Session

Held simultaneously with the Twenty-seventh and Twenty-ninth Sessions

Symposium on Direct Shear Testing of Soils

The desirability of a full discussion of the subject of direct shear testing of soils became apparent at the meeting of Committee D-18 on Soils for Engineering Purposes during the 1951 Annual Meeting. Widely separated ideas as to the value of direct shear testing were presented. Some have abandoned the test entirely as being useless, while others use the method in the major portion of their investigations. The papers listed below are designed to cover as broad a range as possible, each discussing some phase of the subject, and thereby showing the usefulness or the limitations of direct shear tests.

The Place of Direct Shear Testing in Soil Mechanics. D. M. Burmister, Columbia University.

The purpose of this paper is to indicate first, the limitations of the direct shear test; second, the general areas in stability problems in which the direct shear test has applications; and third, the possibilities of making the test data more useful and more directly applicable to the analysis of stability problems by controlled test methods. In view of the fact that the behavior and performance characteristics of soils of essentially granular character and soils of essentially clayey character are so markedly different, they are treated separately in order to bring out the nature of the testing problems involved and the application of the test data to practical problems.

Use of Direct Shear Tests in Highway Design. E. S. Barber, University of Maryland.

Illustrations are given of the use of direct shear tests on soils for determining friction on solids, passive resistance on spiral surfaces, critical density, effect of gradation, slope stability for swelling or fractured clays, and lateral pressure from fill on soft soil. The use of direct shear tests in calculating stability of consolidating soils under various boundary conditions, including vertical sand drains, is outlined in some detail.

While for some purposes the triaxial test is preferred, the direct shear test is more convenient, especially where consolidated tests are required. Improved usefulness will result from further research and correlation with field experience.

The Use of Direct Shear Tests in Earth Work Projects Under Construction. R. R. Proctor, Los Angeles Department of Water and Power.

The design of a direct shear machine to simulate as nearly as possible the failure of compacted fills and foundation soils in an earthfill dam is described. Methods are described for placing compacted fill and undisturbed foundation samples in the equipment for shear test at the same density and under the same loading as they would have at the possible points of failure in the structure. Methods for determining the factor of safety in a typical earthfill dam cross-section for each sample of soil tested are shown, together with a typical summary of actual test results applied to one structure.

The Strength of Gravel in Direct Shear. R. G. Hennes, University of Washington.

For many engineering purposes it is not feasible to measure the shear strength of sand and gravel in the laboratory. This paper describes an attempt to correlate internal friction with grain size and shape, thus providing rough estimates of internal friction on the basis of mechanical analyses. Direct shear tests on rounded gravel of uniform size gave values approaching those for crushed basalt of the same size. Clean aggregates of uniform size are more stable than clean graded aggregates of the same maximum particle size.

A Direct Shear Test with Drainage Control. Donald Taylor, Massachusetts Institute of Technology.

Shearing strength data are presented as a function of intergranular pressure on the sample just before start of shear and maximum intergranular pressure in the past. Strengths by "controlled" direct shear tests, with prevention of change in sample thickness used to approximate a no-drainage condition during shear, are shown to be in reasonable agreement with triaxial test results.

Results of controlled and uncontrolled direct shear tests are compared to demonstrate that without control unacceptable irregularities are introduced by variable factors, the most important one being the amount of direct pressure on the sample during shear.

The Use of the Direct Shear Testing Machine in Foundation Engineering Practice. F. J. Converse, California Institute of Technology.

The time element is frequently an important consideration in the practice of foundation engineering. Where the foundation soils are irregularly bedded and variable in character, many tests are needed and the direct shear testing machine becomes a valuable tool for the determination of the variations in soil strength, because of the speed with which tests can be made. In order to insure accuracy, it is important that the design of the testing machine and the method of test be definitely established. It is urged that the development of such a standard be undertaken by the American Society for Testing Materials.

Thursday, June 26 2:30 p.m. Twenty-ninth Session

Held simultaneously with the Twenty-seventh and Twenty-eighth Sessions

Symposium on Recent Developments in the Evaluation of Natural Rubber

Technical Classification of Crude Natural Rubber. R. G. Newton, International Rubber Research Board.

The paper presents a progress report on the developments which have occurred in the twelve months since the last report was made to Subcommittee XII or Crude Natural Rubber.

Recent world-wide inter-laboratory comparisons have thrown light on the problems of standardizing Mooney and modulus testing, and have emphasized the difficulties of standardizing high-elongation tests. The information gained from these comparisons will be related to present standardizing procedures.

The trend in development of future policy concerning Technically Classified rubber, and of improving the coordination between producer and consumer will be discussed.

Mooney Viscosity Measurements of Technically Classified Rubbers. Rolla H. Taylor, Natural Rubber Investigations of the U. S. Department of Agriculture, and A. G. Veith, The B. F. Goodrich Co.

Mooney viscosity measurements of technically classified natural rubbers are essentially in the same state of development as were the Mooney viscosity measurements of GR-S in 1944. We have a machine capable of doing the job.

This paper reviews the methods of adjusting and operating the machine. The effects of such things as die closure, calibration, temperature, dimension of parts, and sample preparation are discussed.

Technically Classified Rubber: The Non-Rubber Content and the Measurement of Cure Rate. A. G. Veith, The B. F. Goodrich Co.

This characterization has shown that the nonrubber content of a typical set of samples of Technically Classified rubber increases in the order of Red, Yellow, and Blue. Increased quantities of these nonrubber materials appear to promote faster rates of cure. The rate of cure of these samples of Technically Classified rubber has been measured by several methods, all methods yielding data that are in qualitative agreement. The application of a new approach to the general problem of rate of cure, as outlined by G. Gee, has been made. Data are presented which indicate that two of the parameters of Gee's equation for the calculation of cure rate are amenable to measurement with the Mooney Viscometer at moderate curing temperatures, when the ACS No. 1 type of mix is employed.

Vulcanization Characteristics of Natural Rubbers. Robert D. Stiehler and Frank L. Roth, National Bureau of Standards.

Three methods are being considered for the evaluation of natural rubbers. One advanced by The B. F. Goodrich Co. is based on the change in Mooney viscosity during the initial vulcanization period. The second method, proposed by the British Rubber Producers' Research Assn., is based on the Mooney viscosity of the compound and the time of cure and value for maximum modulus of the vulcanizates. In each of these methods two parameters are determined. The third method which determines three parameters, is based on the strain test developed by the National Bureau of Standards.

Four rubbers were evaluated by these three methods. The evaluations were made for two times of storage before vulcanization, two ambient humidity conditions during storage, and two temperatures and seven periods of vulcanization.

Quantitative Procedures for the Determination of Dirt in Crude Natural Rubber. R. P. Stock, The B. F. Goodrich Co., C. O. Miserentino, Dunlop Tire and Rubber Corp., C. B. McKeown, The B. F. Goodrich Co., J. J. Hoesly, The Goodyear Tire and Rubber Co., R. T. LaPorte, Sieberling Rubber Co., and G. H. Wallace, Firestone Tire and Rubber Co.

Subcommittee XII on Crude Natural Rubber of ASTM Committee D-11 on Rubber and Rubber-like Materials appointed a task group to study methods of determining foreign material (sand, dirt, bark, etc.) in crude natural rubber. This six-man group provided test procedures and blended samples to six cooperating laboratories for evaluation. The results of this round-robin testing program indicate two methods which give reproducible data within practical limits.

Both of the selected methods reduce the solid crude rubber sample to a liquid which can be strained through a 325-mesh screen. The amount of dirt retained on the screen may then be determined.

Preparation of a Standard Natural Rubber. E. M. McColm, United States Rubber Co.

Various possible methods are discussed for producing a standard natural rubber, and a detailed description is given of the procedure used in preparing a uniform rubber by spraying a bulked lot of creamed formaldehyde-preserved latex. Three test lots of dry rubber from this single lot of bulked latex have been prepared and subsequently tested at the National Bureau of Standards. The data indicated that satisfactory uniformity had been achieved.

Some Aspects of the Testing of Natural Rubber. Leslie V. Cooper, Firestone Tire and Rubber Co.

Many rubber technologists still use tension determinations on the crude rubber ACS mix as a criterion of quality. To obtain the correct tension figures certain precautions must be taken to eliminate practices and conditions which tend to give premature breaks. The first part of the paper deals with the technique employed at Firestone to get consistent high results.

Much has been written on the evaluation of the effect of exposure to weather on cured natural rubber and synthetic substitutes. The second part of the paper discusses the design and operation of the Firestone Weathering Machine, which we feel can simulate any single condition or combination of conditions which rubber products may encounter in service.

Rubber Evaluations with an Instron Tester. S. D. Gehman, and R. P. Clifford, The Goodyear Tire and Rubber Co.

An investigation was undertaken to explore new opportunities for the evaluation of rubber from its stress-strain characteristics with an Instron Tester. The resistance strain-gage load recording system and the flexibility of control of the crosshead motions introduce a variety of possibilities not available with the usual pendulum type of rubber tester.

Illustrative results from these various procedures are given to point out the versatility and flexibility in testing with this equipment. They indicate important fields of usefulness for it in rubber testing other than routine testing for ultimate elongation and tensile strength for which it is not particularly well adapted.

Thursday, June 26 5:00 p.m. Thirtieth Session

Held simultaneously with the Thirty-first Session

Report Session

Report of Committee C-2 on Magnesium Oxychloride and Oxysulfate Cements. L. S. Wells, Chairman.

Report of Committee C-3 on Chemical-Resistant Mortars. F. O. Anderegg, Chairman.

Report of Committee C-8 on Refractories. R. B. Sosman, Chairman.

Report of Committee C-11 on Gypsum. L. S. Wells, Chairman.

Report of Committee C-14 on Glass and Glass Products. L. G. Ghering.

Report of Committee C-16 on Thermal Insulating Materials. E. R. Queer, Chairman.

Report of Committee C-17 on Asbestos-Cement Products. H. R. Snoke, Chairman.

Report of Committee C-18 on Natural Building Stones. L. W. Currier, Chairman.

Report of Committee C-19 on Structural Sandwich Constructions. A. G. H. Dietz, Chairman.

Report of Committee C-20 on Acoustical Materials. H. A. Leedy, Chairman.

Report of Committee C-22 on Porcelain Enamel. W. N. Harrison, Chairman.

Report of Committee D-1 on Paint, Varnish, Lacquer, and Related Products. W. T. Pearce, Chairman.

Report of Committee D-5 on Coal and Coke. W. A. Selvig, Chairman.

Report of Committee E-6 on Methods of Testing Constructions. J. A. Liska, Chairman.

Thursday, June 26 5:00 p.m. Thirty-first Session

Held simultaneously with the Thirtieth Session

Report Session

Report of Committee B-1 on Wires for Electrical Conductors. D. Halloran, Chairman.

Report of Committee B-2 on Non-Ferrous Metals and Alloys. Bruce W. Gonser, Chairman.

Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. K. G. Compton, Chairman.

Report of Committee B-4 on Electrical Heating, Resistance, and Related Alloys. S. A. Standing, Chairman.

Report of Committee B-6 on Die-Cast Metals. J. R. Townsend, Chairman.

Report of Committee B-7 on Light Metals and Alloys, Cast and Wrought. L. V. Williams, Chairman.

Report of Committee B-8 on Electrodeposited Metallic Coatings. C. V. Sample, Chairman.

Report of Committee B-9 on Metal Powders and Metal Powder Products. W. A. Reich, Chairman.

Report of Committee E-5 on Fire Tests of Materials and Construction. A. L. Brown, Chairman.

Thursday, June 26 8:00 p.m. Thirty-second Session

Held simultaneously with the Thirty-third Session

Concrete

Creep and Non-Linear Behavior of Concrete. A. M. Freudenthal, Columbia University.

Cracking in Masonry Caused by Expansion of Mortar. J. W. McBurney, National Bureau of Standards.

The effect of free magnesium oxide (MgO) in causing the expansion of hardened masonry motars is discussed. From Information available in the literature from the results of length change measurements on brick piers laid with mortar containing MgO, and from the examination of buildings, including laboratory tests of masonry materials, it is concluded that the delayed hydration of MgO can cause expansions of sufficient magnitude to produce severe cracking and structural damage in masonry. Some other causes of cracking are listed and the probable origin of certain openings between units and mortar joints are considered. Recommendations for the prevention of trouble from expansive mortars are offered.

Chemical Test for Alkali Reactivity of Pozzolans. Richard C. Mielenz, K. T. Greene, E. J. Benton, and Fred H. Geier, Bureau of Reclamation.

A chemical test is described which will determine the ability of a pozzolan to control expansion of mortar resulting from reaction between cement alkalies and aggregate. The procedure involves continuous agitation of a mixture of a pozzolan sample, solid calcium hydroxide, and a 0.5 *N* solution of sodium hydroxide at 80 C for 24 hr. The filtrate from the reacted mixture is analyzed for dissolved silica and concentration of sodium and potassium. The net reduction in concentration of alkali and the concentration of silica in solution are used to calculate a reactivity factor which correlates satisfactorily with the expansion of moist-stored mortar bars containing the pozzolan in combination with high-alkali cement and reactive aggregate.

Report of Committee C-1 on Cement. R. R. Litehiser, Chairman.

Proposed Methods for Determining the Sulfate Resistance of Portland Cements. David Wolochow, National Research Council.

The results of cooperative tests carried out by the Working Committee on Sulfate Resistance (ASTM Committee C-1 on Cement) are presented and discussed. The two procedures employed, a lean mortar-bar expansion test and a sulfate susceptibility test, are described and it is suggested that both methods may be suitable for specification purposes.

Report of Committee C-12 on Mortars for Unit Masonry. J. M. Hardesty, Chairman.

Efflorescence. F. O. Anderegg, Consulting Specialist on Building Materials Research.

Report of Committee C-7 on Lime. W. C. Voss, Chairman.

Report of Committee C-9 on Concrete and Concrete Aggregates. Keneth B. Woods, Chairman.

Sanford E. Thompson Award.

A General Analytic Solution for Mohr's Envelope. Glenn Balmer, Bureau of Reclamation. [By title only].

Report of Committee C-15 on Manufactured Masonry Units. J. W. Whittemore, Chairman.

Report of Committee D-4 on Road and Paving Materials. C. E. Proudley, Chairman.

Report of Committee D-8 on Bituminous Waterproofing and Roofing Materials. A. S. Steiner, Chairman.

Thursday, June 26 8:00 p.m. Thirty-third Session

Held simultaneously with the Thirty-second Session

Corrosion and Creep of Metals

A Method of Evaluating Corrosion Test Results. M. A. Cordovi, Babcock & Wilcox Co.

The conventional laboratory methods are not suitable for measuring the extent of corrosion (depth of penetration) caused by bismuth-base liquid metals in iron and steel. In this paper is described a novel type corrosion sample and test procedure which was developed and has been successfully used in work of this kind at Brookhaven National Laboratory. Application of the new method is also suitable for the evaluation of results from other types of corrosion and high-temperature oxidation tests.

Atmospheric Corrosion of Steel Wires. A. P. Jahn, Bell Telephone Laboratories, Inc.

Summarizes the results to date of an atmospheric Exposure Test of Wire and Wire Products now in its fifteenth year. The test, under the auspices of Committee A-5 on Corrosion of Iron and Steel of the ASTM, has a large number of wire and wire products exposed at eleven locations spotted throughout the country from coast to coast. The wires are mostly galvanized steel, but other types of coatings and some stainless steels are also included.

The tests at some sites are almost completed; wires at other sites have as yet shown very little corrosion. The data already collected from these tests has been summarized, analyzed, and condensed.

Atmospheric Corrosion of Low Alloy Steels. H. R. Copson, International Nickel Co.

In 1941 five sets of 71 low-alloy steels were exposed to the industrial atmosphere at Bayonne, N. J., and to the marine atmosphere at Block Island, R. I. Complete sets of specimens were removed at 1, 5, and 9 yr, partial sets at 3 and 7 yr, and a few additional specimens at irregular intervals. The present paper gives complete results through 9 years. This includes weight losses, pit depths, thickness measurements, calculated pitting factors, and the weight of rust on the specimens. Detailed weight loss *versus* time curves, pit-depth time curves, and weight loss composition curves are plotted.

Creep-Tensile Relations at Low Temperatures. J. D. Lubahn, General Electric Co.

In metallurgically stable copper, the creep curves at various stresses can be calculated from a tension curve and from the rate sensitivity—rate sensitivity being determined by suddenly changing the tension testing rate and measuring the stress change. Preliminary results encourage the idea that creep curves can be calculated as above but the results are still inconclusive.

In 61ST, which strain ages, one of the relationships used in the above calculations: namely,

$$\frac{\left(\dfrac{d \log S}{d \log \epsilon}\right)_{\dot{\epsilon}}}{\left(\dfrac{d \log S}{d \log \dot{\epsilon}}\right)_{\epsilon}} = \left(\frac{d \log \dot{\epsilon}}{d \log \epsilon}\right)_S$$

does not apply, but since $(d \log \dot{\epsilon}/d \log \epsilon)_S$ is independent of the creep stress and constant

during the test, the creep curve for any stress can be calculated from the tension curve and one measured creep curve.

The Influence of Periodic Overstressing on the Creep Properties of Several Heat Resistant Alloys. G. J. Guarnieri and L. A. Yerkovich, Cornell Aeronautical Laboratory, Inc.

The intermittent overloads encountered in the operation of jet aircraft create certain problems of predicting the life expectancy of structural materials exposed to high-temperature service. Test equipment and procedures were developed under sponsorship of the Bureau of Aeronautics, U. S. Navy, for conducting creep-rupture overload tests in order to investigate the effects of the variables involved and to provide actual design-type high-temperature data. Such results were obtained for 347 stainless steel sheet at 1200 and 1500 F, N-155 sheet at 1500 and 1800 F, and cast vitallium at 1500 F. It was possible to correlate and present the data in conventional design chart form with coordinates of normal stress *versus* time for various amounts of deformation and rupture. Included in such charts were the parameters of the overstress to normal stress ratio and the percentage of time of overstress application.

Report of Committee A-3 on Cast Iron. J. S. Vanick, Chairman.

Report of Committee A-5 on Corrosion of Iron and Steel. T. R. Galloway, Chairman.

Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys. Jerome Strauss, Chairman.

Friday, June 27 9:30 a.m. Thirty-fourth Session

Symposium on Exchange Phenomena in Soils

Report of Committee D-18 on Soils for Engineering Purposes. E. J. Kilcawley, Chairman.

Symposium on Exchange Phenomena in Soils

Like zeolites and some organic compounds, clay minerals adsorb ions and organic molecules from solutions and simultaneously release equivalent numbers of ions and molecules from their own substance. In nature, clay minerals of soils and geologic formations exchange ions and molecules continuously in response to changing concentration of dissolved solids in ground water. Similarly exchange can be effected artificially by surface applications, injection of solutions, or electrical treatments. Exchange phenomena in soils are critically important to the soils mechanics engineer and to the designer and construction engineer he serves, because exchangeable ions and molecules in clays determine to a significant degree the engineering performance of earth materials in foundations, slopes, and embankments.

Ion Exchange in Relation to Some Properties of Soil-Water Systems. Ralph E. Grim, University of Illinois.

The phenomenon of ion exchange as it applies to the clay mineral constituents of soils is discussed.

The physical properties, such as plasticity, compaction, etc., of soil-water systems to a considerable degree are a function of the forces attracting the clay mineral particles to each other, of the thickness of the water envelope around the clay mineral particles, and of the nature of the water itself. The character of the adsorbed water and its influence on the physical properties are considered.

It is well known that the physical properties of soils are influenced to varying degrees by the kind of exchangeable ions present, and the properties can sometimes be changed enormously by changing the adsorbed ions. The importance and manner of operation of the effect of exchangeable ions in soil mechanics problems are considered.

Cation Exchange Capacity in Loess and Its Relation to Engineering Properties. Donald T. Davidson and John B. Sheeler, Iowa State College.

The origin, distribution, and physical and chemical properties of the deep Wisconsin (or Peorian) loess in southwestern Iowa are briefly presented. Prior to discussing the variation of cation exchange capacity in the loess, a brief summary of present knowledge of cation excange in soils is given followed by a detailed explanation of the methods used in measuring the exchange capacity of loess samples.

The property data for the Wisconsin loess afford an unusual opportunity for presenting correlations of cation exchange capacity with the following engineering properties: amount of 0.002-mm clay, liquid limit, plastic limit, plasticity index, shrinkage limit, centrifuge moisture equivalent, field moisture equivalent, hygroscopic moisture, in-place density, and field moisture content.

Job Experience with Exchange Phenomena Involving Inorganic and Organic Ions. Hans F. Winterkorn, Princeton University.

Surface-Chemical Properties of Clay Minerals and Soils as Revealed by Recent Experimental and Theoretical Developments in Electro-Osmosis. Hans F. Winterkorn, Princeton University, and Gerhard Schmid, Technische Hochschule, Stuttgart, Germany.

Friday, June 27 11:30 a.m. Thirty-fifth Session

Report Session

Report of Committee D-2 on Petroleum Products and Lubricants. O. L. Maag, Chairman.

Report of Committee D-3 on Gaseous Fuels. A. W. Gauger, Chairman.

Report of Committee D-11 on Rubber and Rubber-like Materials. Simon Collier, Chairman.

Report of Committee D-12 on Soaps and Other Detergents. J. C. Harris, Chairman.

Report of Committee D-15 on Engine Antifreezes. H. R. Wolf, Chairman.

Report of Committee D-16 on Industrial Aromatic Hydrocarbons. D. F. Gould, Chairman.

Report of Committee D-17 on Naval Stores. V. E. Grotlisch, Chairman.

Report of Committee D-21 on Wax Polishes and Related Material. W. W. Walton, Chairman.

Friday, June 27 2:30 p.m. Thirty-sixth Session

Symposium on Test Methods for Process Control in Ceramic Whitewares

Report of Committee C-21 on Ceramic Whiteware. J. H. Koenig, Chairman.

Symposium on Test Methods for Process Control in Ceramic Whitewares

The Status and the Importance of Terminology and Ceramic Whitewares. Arthur S. Watts, Ohio State University.

A serious state of confusion in whiteware terminology has developed. The general situation and some of the most erxteme cases are presented and the program and progress of the ASTM Committee C-21 on Ceramic Whitewares for the development of standard terminology in products, processes, and properties are presented.

Possibilities for Adapting Research Tools for Process Control Evaluations. John H. Koenig, Rutgers University.

Report on Round-Robin Investigation of Modulus of Rupture Tests of Ceramic Specimens. Rolland R. Roup, Glove-Union, Inc.

Report on Round-Robin Investigation on Methods of Evaluating Sub-Sieve Particle Sizes of Nonplastic Materials. C. J. Koenig, Ohio State University.

Comparisons are drawn on the subsieve particle sizes of a sample of pottery flint as evaluated by the following methods: (1) the Andreasen pipette method, (2) hydrometer method, (3) hydrometer method in conjunction with a centrifuge, (4) microscopic count, (5) "Roller" particle size analyzer (American Instrument Co. Inc.), (6) micro particle classifier (Harry W. Dietert Co.), (7) total surface area by the dry nitrogen method, and (8) the Fisher subsieve sizer (Fisher Scientific Co.).

Evaluation of the Critical Properties of Clay. T. A. Klinefelter, U. S. Bureau of Mines.

The critical properties of whiteware clays vary in their importance with the particular body and the proportions in which the clays are used. The usual critical properties in the prefire stage are plasticity, castability, strength, and shrinkage and after heat treatment are vitrification color, thermal expansion, dielectric properties, and refractoriness. The various methods and procedures for evaluating these properties are discussed.

Report on Committee Investigation of Process Control in the Whitewares Industry. C. H. Commons, Jr., General Electric Co.

Biographical Briefs of 50th Anniversary Meeting Guest Speakers

Detlev W. Bronk

DR. BRONK, president of The Johns Hopkins University, is noted internationally for his work in biophysics. He is president of the American Association for the Advancement of Science, and of the revered National Academy of Sciences, and was formerly chairman of the National Research Council. In recognition of his leadership in scientific research and development, President Truman appointed Dr. Bronk to the executive committee of the National Science Foundation, organized in 1950 to advise the Federal Government on defense problems.

Born in New York City, Dr. Bronk received his B.A. degree from Swarthmore College and while still an undergraduate served as a naval aviator in World War I. His scientific career began in 1921 when he went to the University of Michigan as a graduate student and instructor in the physics department where he collaborated with Drs. Walter F. Colby and Charles F. Myers in their early studies of rotation spectra in the infrared. The resulting paper by the collaborators is a classic in infrared spectroscopy and gave rise to the theory of half quantum numbers. While at Michigan Dr. Bronk became interested in physiology and earned his Ph.D. there in both physics and physiology.

In 1926 he went to London as a National Research Council Fellow to work with A. V. Hill in the study of heat produced by muscle and upon his return to this country he became professor of biophysics and Director of the Eldridge Reeves Johnson Foundation at the University of Pennsylvania where he continued his work on the action of single neurones, studying in detail the mechanisms responsible for the regulation of blood pressure and respiration.

Dr. Bronk has served his country in numerous research and advisory groups at the national level and has held office in many scientific societies both here and in Europe. At present he is also associated with ten physiological journals in an editorial capacity. In recognition of his significant contributions to science and education, twelve U. S. universities and medical schools have conferred honorary degrees on Dr. Bronk.

Robert C. McMaster

DR. R. C. MCMASTER is Supervisor of the Electrical Engineering Division and the nondestructive test development laboratory at Battelle Memorial Institute, Columbus, Ohio. Dr. McMaster obtained his Ph.D. degree from the California Institute of Technology and has participated in the development of X-ray and other nondestructive test methods during the past ten years. Methods developed for radiographing of spot welds in light-alloy aircraft sheet materials which were adopted in military fluoroscopic methods of examination of aircraft castings and forgings, have been adopted by a major manufacturer for inspection of civil aircraft components. Other nondestructive test developments have been concerned with the application of ultrasonics, fluorescent magnetic particles, and electromagnetic induction methods to industrial inspection problems.

Prior to joining Battelle's staff, Dr. McMaster served with the General Electric Co. and the Naval Ordnance Laboratory, and, for four years, supervised the million-volt laboratory and lightning research at the California Institute of Technology. He has also taught electrical engineering at Case Institute of Technology, in war training classes and in the Graduate School of the California Institute of Technology.

At Battelle, Dr. McMaster has participated in studies of the fatigue of aircraft structures; of corrosion fatigue failures of oil well drill pipe; of high-speed, high-temperature testing of metallographic materials; and of other problems in industrial physics. More recently he has supervised studies of transformer core materials, mechanical rectifiers, powdered permanent magnetic materials, ultrasonics, power systems, and electronics.

Norman L. Mochel

NORMAN L. MOCHEL, a native of Pittsburgh, Pa., was first employed in his home city in the Inspection Department, of the then Westinghouse Machine Co. He later was responsible for the work of testing materials with that company and has for many years held his present position as Manager of Metallurgical Engineering with the Westinghouse Electric Corp.

During World War I, Mr. Mochel saw service overseas with the Corps of Engineers and in World War II rendered invaluable service in a civilian capacity to several branches of the Government and to the Armed Forces. One of his most outstanding contributions at that time was to the National Emergency Steel Specifications work. Valuable services were also rendered to other groups, particularly to the National Advisory Committee on Aeronautics and the United States Navy.

Mr. Mochel also has a long and full record of service in ASTM of which he is at present a director. He has been for a number of years chairman of Committee A-1 on Steel and was for many years chairman of the Joint ASTM-ASME Committee on Effect of Temperature on Properties of Metals, in which he still takes an active part. At the present time he is also a member of the ASTM Ordnance Advisory Committee.

Mr. Mochel has written numerous technical papers, one of which, "The High-Temperature Fatigue Strength of Several Gas Turbine Alloys," written with P. R. Toolin in 1948, won the ASTM Charles B. Dudley Medal for the outstanding paper on research in that year.

Among other organizations in which Mr. Mochel is active are the American Welding Society and the American Society for Metals.

Rufus E. Zimmerman

RUFUS E. ZIMMERMAN, Vice-President of United States Steel Co., was born in Mount Pleasant, Pa., and received degrees from Franklin and Marshall College and Massachusetts Institute of Technology. After three years as instructor in physical chemistry at MIT Mr. Zimmerman joined the American Sheet and Tin Plate Co., as research associate. In 1919 he became Director of Research of that company, and in 1922 was made Assistant to Vice-President, Operations. After ten years in that position, he was appointed Assistant to President, United States Steel Corp. in New York, and in 1933 became Vice-President. Upon the formation of the United States Steel Corp. of Delaware in 1938, Mr. Zimmerman was made Vice-President, Director, and Member of the Executive Committee. The United States Steel Co., a new consolidation of several subsidiaries of the parent corporation, initiated its activities in 1951 and Mr. Zimmerman became Vice-President, a Director, and Chairman of the Research Policy Committee.

During the First World War, he was consulting chemical engineer for the United States Bureau of Mines. He was a member of the Metallurgical Advisory Board of the Carnegie Institute, Member Advisory Board Princeton Engineering Assn., Member Board of Directors and Past-President, American Standards Assn, Trustee Industrial Foundation of America, Member National Engineers Committee, Member Advisory Committee on Standards—U. S. Department of Commerce, Member Advisory Committee Department of Quartermaster General during Second World War, former Member Advisory Board Army Industrial College, and of the Research Committee of the Army Ordnance Association.

Technical societies of which he is a member are the American Iron and Steel Institute, American Chemical Society, the Electrochemical Society, American Institute of Mining and Metallurgical Engineers, American Society for Metals. On Nov. 21, 1946, he received the American Society for Metals' Medal for Advancement of Research.

Albert Caquot

BIOGRAPHICAL MATERIAL on M. Caquot appeared on page 6, April ASTM BULLETIN.

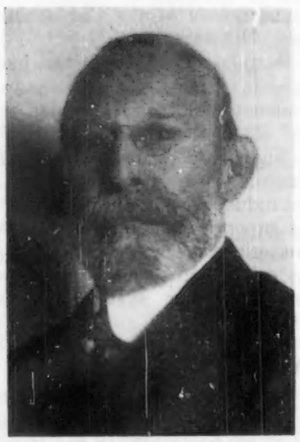
Founder Members

EDGAR MARBURG
(1864–1918)
First Secretary-Treasurer 1902–1918
Head, Civil Engineering Department
University of Pennsylvania

HENRY M. HOWE
(1848–1912)
President 1910–1912
Professor of Metallurgy, Columbia University

MANSFIELD MERRIMAN
(1848–1925)
President 1915–1916
Honorary Member 1919
Professor of Civil Engineering, Lehigh University

1902



CHARLES B. DUDLEY
(1842–1909)
First President 1902–1909
Chief Chemist and Metallurgist in Charge of Testing and Research, Pennsylvania Railroad Co.

1952

ALBERT L. COLBY
(1860–1924) Consulting Engineer and Iron and Steel Metallurgist

WILLIAM R. WEBSTER
(1855–1933)
Honorary Member 1927
Consulting and Testing Engineer

ROBERT W. LESLEY
(1853–1935)
Honorary Member 1927
Director and President, Giant Portland Cement Co.

Brief Statement of Events, People and Places Pertinent to the Fiftieth Anniversary of the American Society for Testing Materials

50 Years Concentration on Materials, Standards, and Research

SINCE its formal incorporation in the Commonwealth of Pennsylvania, March 21, 1902, ASTM has concentrated its work on the promotion of knowledge of the materials of engineering and the standardization of specifications and the methods of testing. Even in this seemingly restricted field, the Society has found more than enough to occupy the attention of its members and staff. This concentration of effort underlies, to some extent at least, the great influence of the Society.

Standards are Dynamic

WORTH-WHILE standards, whether pertaining to quality or testing, or dimensional, are not static and fixed, but dynamic. They do not retard initiative and development, but rather provide a resting place while research and initiative forge ahead. As developments and advances take place, standard requirements are revised.

ASTM Formed in Chaotic Period!

FORMED as an American Committee of the International Association for Testing Materials in 1898, it was evident to the American group that a separate and independent Society could best carry out the work on standardization of specifications. Other countries were interested in research and test methods, but as Arthur N. Talbot, revered long-time Dean of Engineering at the University of Illinois, and former ASTM President, wrote:

"Few of the younger generation realize conditions attending the purchase and use of engineering materials as late as the last years of the nineteenth century. Regardless of information possessed in some lines and of satisfactory relations between many sellers and buyers, the general conditions of that time might be called primitive when compared with present practice. Variability in the products offered by the producer and variability in the demands of the consumer, sales talk of seller and flat demands of the buyer, trade-mark products and 'acceptable to the buyer,' paucity of knowledge of properties of products and even ignorance of needed requirements, differences in view-point of buyer and seller, and inability to make definite specifications satisfactory to both—all these and many other differences of view were symptoms of the semi-chaotic condition in the relations between buyer and seller. Under such circumstances it was not strange that the American Section of the International Association for Testing Materials that first met in 1898 quickly changed into the American Society for Testing Materials in 1902, especially as the intervening years were times of increasing activity in industrial and constructional work."

Membership World-Wide: Leading Americans Members

CURRENTLY, there are about 7200 ASTM members largely concentrated in the United States and Canada, but with many throughout the world. About 5150 are individuals, Government departments, libraries, etc., classed as individuals; about 1800 companies, associations; and 250 Sustaining Members; about 120 individuals are Junior Members. Not included in these figures are some 650 Student Members at leading technical schools.

Many of the members have been or are world or nationally famous, including Henry Ford; C. F. Kettering; Herbert Hoover; Thomas A. Edison; W. A. Irvin, former President, U. S. Steel Corp.; Morris E. Leeds; G. H. Clamer, President, Ajax Metal Co.; George K. Burgess, Director, National Bureau of Standards, etc. The current President of the National Association of Manufacturers, W. J. Grede, is an active ASTM member.

A classification of the membership indicates that approximately 20 per cent are in management or executive positions; about 55 per cent are technical and engineering personnel; about 25 per cent professors, sales, Government, libraries, etc.

Over 2000 Committees Include Consumers and Producers

MANY have said that the ASTM technical committees are the heart blood of the Society. It is true that in these groups is concentrated great authority and autonomy for both standardization and research activities. Currently there are probably at least 2000 main committees, sections, and related subgroups. One of the basic reasons for the widespread acceptance of ASTM standards is in the make-up of the technical committees which originate and draft standards. It is the rule that there shall be adequate representation by technical men representing both the producer and consumer, with a third independent or general interest group adequately represented.

Wars Stimulate Standards

BOTH recent World Wars stimulated the development and use of standards for materials. In 1917 there were 133 ASTM standards, while in December, 1940, the year before Pearl Harbor, there were 952 standards and tests available for use by industry and the Government Services. Now there are about 1850 standards, so that in the last approximate 10-year period, there were as many standards made available as in the 22 years between World Wars I and II. This growth has resulted in a greatly expanded Book of ASTM Standards, the official book of specifications. The 1952 edition (available late this year) will aggregate some 10,000 pages in 7 Parts.

Society's Staff and Headquarters Expanding

THE present Headquarters Staff of about 60 occupies the Society's own building at 1916 Race St., Philadelphia 3, Pa., on the Parkway. Acquired in 1946, the building was financed through contributions from the members. Recently, the Society procured additional land adjacent to the building for pending expansion required by increased activity and larger Staff. The Philadelphia Academy of Natural Sciences flanks the Headquarters on one side and diagonally across Logan Square are the Philadelphia Public Library and the Franklin Institute.

Government Branches Active in ASTM

MANY branches of the Federal and state and municipal Governments participate in ASTM work through representation on technical committees. Outstanding is the active and constructive interest of the National Bureau of Standards, Washington, D. C. The Armed Services, Bureau of Public Roads, and other Federal departments have and continue to make notable contributions to ASTM work. Virtually every state highway department in the United States is represented.

In August, 1944, the Society received the U. S. Ordnance Army Distinguished Award and in 1946, the United States Navy tendered ASTM a Certificate of Achievement.

Color—and More Color

ASTM Exhibits Work in Color

Over 350 color-conscious men and women from industry, Government, and education assembled at the Statler in New York early in February. The occasion was the 21st annual conclave of the Inter-Society Color Council, a group devoted to the stimulation and coordination of technical work being done by the various societies, organizations, and associations in the field of color. The theme of the meeting, admirably supported by technical papers and exhibits was: "Color in Science, Art and Industry."

Three papers were read dealing respectively with the relation of color to human efficiency, graphic reproduction, and textile dyeing. The latter paper, read by E. I. Stearns, Chairman of the Council, had the intriguing title of "Dyeing for a Living: Color in Textiles." The two papers in the afternoon had an international flavor. The first dealt with some aspects of the 1951 Meeting of the International Commission on Illumination which took place in Stockholm, while the second on color discrimination was read by W. D. Wright, Imperial College of Science and Technology, London, England.

In other Sessions, eight papers were presented dealing with color in vegetable oils, color perception, color in merchandising, in motion pictures, in interior decoration, in artist's pigments, in color photography and finally with color phenomena in general. At the business session of the Council, ASTM delegate M. Rea Paul presented his report on ASTM activities.

An important feature of the meeting was a group of exhibits prepared by the Member Bodies and committees of the Council. These consisted of models, charts, motion pictures, and publications, all prepared to represent graphically color standards used successfully in the different fields or representative color problems either solved or unsolved. Fifteen member bodies of the council had exhibits, and five ISCC Subcommittees illustrated color problems in which they are engaged. The exhibit attracting perhaps the widest attention was that of ISCC Subcommittee 10, arranged by F. L. Dimmick, U. S. Medical Research Laboratory, New London, Conn. This group is devoted to the study of color aptitude, and the exhibit was set up to permit guests to take a color aptitude test. The development of the particular test used was illustrated by a series of four different stages in its refinement over the past 12 years.

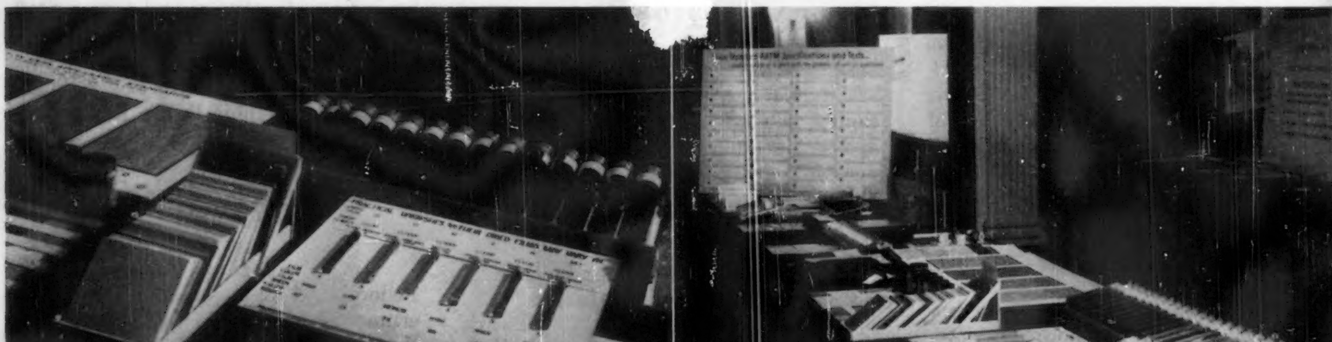
The ASTM exhibit was designed to show the range of standardization activities sponsored by various ASTM committees in the field of color and appearance. Specific ASTM tests and specifications were illustrated for such varied materials as plastics, petroleum, mica, cotton yarn, paint, varnish, and aromatic hydrocarbons. Many ASTM specifications and tests were cited, with actual samples of the materials, as dealing in whole or in part with the problem of color or appearance. It is planned that the same exhibit be shown during the ASTM 50th Anniversary Meeting, at the Statler, June 23–27.

Rapid Determination of Bismuth in Lead-Tin Alloys

A new, rapid spectrophotometric method for the determination of bismuth in lead and tin-base alloys, accurate to within ±0.002 per cent in alloys containing 0.02 to 0.10 per cent of the element, has been developed at the National Bureau of Standards.

Bismuth, added to lead-tin alloys to lower their melting points, promotes spreading in solders, and in type metals prevents contraction of the type face when it solidifies. Larger additions of bismuth, along with cadmium and antimony, to the lead-tin alloys result in the low-melting "fusible" alloys widely used in safety devices.

In the NBS method, which requires only two to three hours of the analyst's time, the specimen is dissolved in a mixture of hydrobromic acid and bromine. Perchloric acid is added and tin, antimony, and arsenic are removed as the volatile bromides. Nitric acid is added and bismuth in the residual solution is then precipitated as the oxychloride. The precipitate is dissolved in nitric acid and the acidified bismuth solution is treated with thiourea to form a yellow complex. The optical absorbency of the colored solution is measured with a filter photometer, and the amount of bismuth is read from an absorbency curve previously prepared by treating known amounts of bismuth with thiourea.



Through the cooperation of members and their companies ASTM was able to exhibit at the Annual Meeting of the Inter-Society Color Council (February 7–9) a wide range of materials involved in ASTM color and appearance work. A section of the exhibit table (above left) shows: polystyrene tiles suitable for color evaluation under D 791 and D 620; cotton yarn appearance standards (D 180); paint panels and dry pigments (D 387); Gardner-Holt tubes and dried varnish films illustrating 60 deg specular gloss (D 523); and lubricating oil suitable for testing under D 155. Other samples exhibited represented ASTM work in such diverse materials as mica, aviation motor fuel, aromatic hydrocarbons, pile floor covering, askarels, naval stores, and ferrous metals. A colorful panel at the rear of the table (above right) listed by title and designation 38 ASTM standard specifications and tests dealing in whole or in part with the problem of color or appearance.

New Standards and Revisions in Plastics, Electrical Insulation, and Paint, Varnish, and Lacquer Fields Approved by Standards Committee

Several new methods and a number of revisions of existing standards submitted by Committees D-1, D-9, and D-20, were approved by the Administrative Committee on Standards at their April meeting.

Plastics:

Committee D-20 on Plastics submitted a new tentative Method of Test for Volatile Loss from Plastic Materials (D 1203). This method, which is now in use by all major manufacturers of plasticizers and nonrigid vinyl plastics and by the U. S. Government, covers a procedure for determining the volatile loss from a plastic material under defined conditions of time and temperature, and utilizing activated carbon as the immersion medium. The method is intended to be a rapid empirical test, useful in the relative comparison of materials having the same nominal thickness.

Also submitted by the Plastics Committee was a Method for Measurement of Changes in Linear Dimensions of Nonrigid Thermoplastic Sheeting and Film (D 1204) which provides for measurement of linear dimension changes in these materials which result from exposure of the material to specified conditions of elevated temperature and time. The test gives an indication of lot to lot uniformity with respect to the degree of internal strains introduced during processing.

Since at the present time there is no specification on a thermosetting molding compound consisting of alkyd resin with filters, Committee D-20 felt it necessary to develop such a specification because of the wide use of this material. Tentative Specifications for Alkyd Molding Compounds (D 1201) cover the following four types of alkyd molding compounds:

Type 1.—General purpose granular material with mineral fillers.

Type 2.—General purpose granular material with mineral and cellulosic fillers and having improved mechanical strength.

Type 3.—General purpose putty-type material with mineral fillers.

Type 4.—Putty-type material with mineral fillers having superior electrical properties.

Revision of Tentative Method of Test for Compressive Properties of Rigid Plastics (D 695) was undertaken at this time in order to provide improvements in the test.

The Method of Test for Brittleness Temperature of Plastics and Elastomers by Impact (D 746) which describes a means for determining a temperature at which plastics and elastomers exhibit brittle failure under specified impact conditions was revised to incorporate the solenoid types of instruments in making the test.

The specifications for Vinylidene Chloride Molding Compounds (D 729) have been revised in Section 4 (*b*) of the specifications to meet present values of Flow Temperature, Tensile Strength, and Heat Distortion Temperature.

Electrical Insulating Materials:

Two new specifications for Enclosures and Servicing Units for Tests Above and Below Room Temperature (D 1197) and for Cellulose Acetate Sheet and Film for Primary Insulation (D 1202) were submitted jointly by Committee D-20 and Committee D-9 on Electrical Insulating Materials. The former replaces standard specifications D 760 and D 761 which are withdrawn, and was proposed because it clearly sets up definite requirements for such units which were not defined properly in the two previous specifications.

The second joint recommendation of the committees provides proper specifications for cellulose acetate which is being used considerably for insulation in certain applications today. The specifications cover one grade suitable for general electrical insulation and two types—namely, cast film and sheet stock, made by calendering, extruding, or sheeting.

Tentative Methods of Testing Molded Materials Used for Electrical Insulation (D 48) was revised by Committee D-9 to provide for the use of a molded disk

Actions by ASTM Administrative Committee on Standards, April, 1952

New Tentatives

Method of:

- Test for Solvent Tolerance of Amine Resins (D 1198 - 52 T)
- Test for Volatile Loss from Plastic Materials (D 1203 - 52 T)
- Measurement of Changes in Linear Dimensions of Nonrigid Thermoplastic Sheeting and Film (D 1204 - 52 T)

Specifications for:

- Alkyd Molding Compounds (D 1201 - 52 T)
- Enclosures and Servicing Units for Tests Above and Below Room Temperature (D 1197 - 52 T)
- Cellulose Acetate Sheet and Film for Primary Insulation (D 1202 - 52 T)

Tentative Revisions of Standards

Method of:

- Test for Diffusion of Light by Plastics (D 636 - 43)
- Test for Luminous Reflectance, Transmittance, and Color of Materials (D 791 - 50)

Revisions of Tentatives

Method of:

- Testing Molded Materials Used for Electrical Insulation (D 48 - 46 T)
- Testing Varnishes (D 154 - 50 T)
- Test for Compressive Strength of Plastics (D 695 - 49 T)
- Test for Brittle Temperature of Plastics and Elastomers (D 746 - 44 T)

Specifications for:

- Vinylidene Chloride Molding Compounds (D 729 - 44 T)
- Venetian Red (767 - 50 T)

Withdrawals

Specifications for:

- Enclosures for Small Testing Machines for Tests at Subnormal and Supernormal Temperatures of Electrical Insulating Materials and Plastics (D 760 - 49)
- Servicing Units for Tests at Subnormal and Supernormal Temperatures of Electrical Insulating Materials and Plastics (D 761-49)

in place of the molded bar specimen now used in the test for insulation and volume resistance.

Paint, Varnish, Lacquer, and Related Products:

The continued growth in the quantity of amine resins used and the increased variety of industrial finishes based on them resulted in the recognition by Committee D-1 on Paint, Varnish, Lacquer, and Related Products of a need for a method of test designed to measure the quantity of hydrocarbon solvent that an amine resin will tolerate at 25 C. The Tentative Method of Test for Solvent Tolerance of Amine Resins (D 1198 – 52 T) was proposed to meet this demand.

Tentative Methods of Testing Varnishes (D 154) was revised with respect to its section on Resistance of Dried Films to Alkali which was no longer adequate.

Tentative Specifications for Venetian Red were revised in order to correct the table of composition and properties with respect to ignition loss.

Method of Test for Diffusion of Light by Plastics (D 636) and Method of Test for Luminous Reflectance, Transmittance and Color of Materials (D 791) were approved for tentative revision to include "significance" statements which they had previously not contained.

Examination and Rehabilitation of Graphitized Welded Joints

A most interesting paper by I. A. Rohrig and R. M. Van Duzer of The Detroit Edison Co. includes a discussion of Detroit Edison procedure for sampling welded joints, testing the sample, and evaluating graphitization. Also the heat treatment, rewelding, and replacement of graphitized joints are discussed.

This paper appears in *Combustion*, Vol. 23, No. 7, January, 1952, pp. 36 to 42. The magazine can be obtained from Combustion Publishing Co., Inc., 200 Madison Ave., New York 16, for thirty cents a copy.

Complete List of Emergency Alternate Standards

Listed below are the Emergency Alternate Standards approved by the Administrative Committee on Standards as this Bulletin goes to press. The issue of the Bulletin in which the alternate provisions were printed in full is given for convenient reference.

Designation	Covers	
EA 26	Steel Tires	October, 1951
EA 158	Seamless Alloy-Steel Pipe for High-Temperature Service	April, 1952
EA 161	Seamless Low-Carbon and Carbon-Molybdenum Steel Still Tubes for Refinery Service	April, 1952
EA 167	Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip	October, 1951
EA 182	Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service	April, 1952
EA 199	Seamless Cold-Drawn Intermediate Alloy-Steel Heat-Exchanger and Condenser Tubes	September, 1951, April, 1952
EA 200	Seamless Intermediate Alloy-Steel Still Tubes for Refinery Service	September, 1951, April, 1952
EA 206	Seamless Carbon-Molybdenum Alloy-Steel Pipe for High-Temperature Service	April, 1952
EA 209	Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes	April, 1952
EA 213	Seamless Alloy-Steel Boiler and Superheater Tubes (Tentative)	September, 1951, April, 1952
EA 217	Alloy-Steel Castings for Pressure Containing Parts Suitable for High-Temperature Service	April, 1952
EA 240	Corrosion-Resisting Chromium and Chromium-Nickel Steel Plate, Sheet, and Strip for Fusion-Welded Unfired Pressure Vessels	October, 1951
EA 249	Welded Alloy-Steel Boiler and Superheater Tubes	September, 1951
EA 250	Electric-Resistance-Welded Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes	April, 1952
EA 268	Seamless and Welded Ferritic Stainless Steel Tubing for General Service	September, 1951
EA 269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service	October, 1951
EA 270	Seamless and Welded Austenitic Stainless Steel Sanitary Tubing	September, 1951
EA 271	Seamless Austenitic Chromium-Nickel Steel Still Tubes for Refinery Service	October, 1951
EA 276	Hot-Rolled and Cold-Finished Corrosion-Resisting Steel Bars (Tentative)	October, 1951
EA 280	Seamless Chromium-Molybdenum Alloy-Steel Pipe for Service at High Temperatures	April, 1952
EA 296	Corrosion-Resistant Iron-Chromium and Iron-Chromium-Nickel Alloy Castings for General Application (Tentative)	October, 1951
EA 312	Seamless and Welded Austenitic Stainless Steel Pipe (Tentative)	October, 1951
EA 314	Corrosion-Resisting Steel Billets and Bars for Reforging (Tentative)	October, 1951
EA 315	Seamless 1 per cent Chromium, 0.5 per cent Molybdenum Alloy-Steel Pipe for Service at High Temperatures	April, 1952
EA 329	Heat-Treated Steel Tires (Tentative)	October, 1951
EA 335	Seamless Ferritic Alloy Steel Pipe for High-Temperature Service	April, 1952
EA 352	Ferritic Steel Castings for Pressure Containing Parts Suitable for Low-Temperature Service	April, 1952
ED 69	Friction Tape for General Use for Electrical Purposes (Tentative)	September, 1951
ED 119	Rubber Insulating Tape (Tentative)	September, 1951

Symposium on Flame Photometry Published

Petroleum and Cement Committees Collaborate

THE practical use of the flame photometer in chemical analysis was given a great impetus during the recent war by the need for rapid accurate analyses of sodium and potassium in blood.

While recognizing that the method had certain limitations, members of ASTM Committees C-1 on Cement and D-2 on Petroleum Products and Lubricants realized the possibility of using the photometer as a new testing method and accordingly arranged a symposium at the 1951 Annual Meeting to make the information available. The papers presented at that time are now published as a Special Technical Publication No. 116.

The opening paper reviews the subject of flame photometry and the second deals with medical use of the method in chemical analysis of biological fluids. The next three papers deal with its use in the cement and materials testing fields.

The balance of the papers, with the exception of the final one on application to water analysis, which was prepared by Committee D-19 on Industrial Waters, pertains to application of flame photometry to petroleum products and lubricants.

The papers and their authors are as follows:

A Review of Flame Photometry—V. M. Meloche

A Stable Internal Standard Flame Photometer for Sodium, Potassium, Lithium, and Calcium Analyses in Biological Fluids and a Study of Ion Interference—C. L. Fox, Jr., E. B. Freeman, and S. Lasker

Use of the Beckman and Perkin-Elmer Flame Photometers for the Determination of Alkalies in Portland Cement—J. J. Diamond and L. Bean

Applications of Flame Photometry for the Analysis of Alkalies in Silicates, Waters, and Metals—J. L. Gilliland

The Determination of Lithium Oxide in Portland Cement by Flame Photometer—W. J. McCoy and G. G. Christiansen

Control of Interferences Caused by Acids and Salts in the Flame Photometric Determination of Sodium and Potassium—F. T. Eggertsen, G. Wyld, and L. Lykken

The Effect of Organic Solvents on the Flame Photometric Emission of Certain Elements—G. W. Curtis, H. E. Knauer, and L. E. Hunter

Determination of Tetraethyllead in Gasoline by Flame Photometry—P. T. Gilbert, Jr.

Determination of Calcium in Lubricating Oil by Flame Spectrophotometer—M. L. Moberg, V. B. Waithman, W. H. Ellis, and H. D. DeBois

A Modified Recording Flame Photometer—W. H. King and W. Priestley, Jr.

Flame Photometer in the Analysis of Water and Water-Formed Deposits—R. K. Scott, V. M. Marcy, and J. J. Hronas

Members may obtain copies of this publication in heavy paper cover at \$1.50; the price to nonmembers, \$2.

Manual of ASTM Standards on Refractory Materials

THIS new edition of the Manual of ASTM Standards on Refractory Materials, dated February, 1952, supersedes the old one printed in 1948, and is published for the primary purpose of bringing together in convenient form all of the ASTM standard and tentative specifications, classifications, methods, and definitions pertaining to refractories.

Pertinent information of recognized value in the testing and use of refractories included covers industrial surveys of refractory service conditions in various types of operations, such as in the incineration of refuse, in the malleable iron industry, lead industry, and in continuous plate glass and window glass furnaces, and proposed and suggested methods and procedures not in the category of ASTM standards. Data are given on a number of standard samples available for chemical analysis purposes, as well as for pyrometric cone equivalent determinations.

New ASTM tentatives added in the 1952 edition include methods of test for modulus of rupture and for permanent linear change on firing of castable refractories. The latest revisions of several of the older standards will also be found in this edition.

Specifications cover refractories for boiler service and incinerator service; classifications cover fireclay refractories and insulating fire brick; test methods cover: fireclay refractory brick (high heat duty, super duty, thermal conductivity); mortars and fireclay plastic and castable refractories (drying and firing shrinkage, fireclay plastic refractories, workability index, etc.); insulating fire brick; applicable to various types of refractory materials. Also included are suggested procedures, definitions, a proposed method of test for disintegration of fireclay refractories in an atmosphere of carbon monoxide, standard samples of refractory materials, proposed glossary, and industrial surveys of refractory service conditions.

The price of this 306-page book to members, heavy paper cover, is \$2.25 per copy; list, \$3. For cloth cover, add 65 cents to each of these prices.

Index to ASTM Standards Being Mailed

THE combined Index to the 1949 ASTM Book of Standards and all its 1950 and 1951 Supplements, comprising about 284 pages, is off press, and has been put in the mails to each ASTM member and committee member.

This 1951 Index covers all the current standards in the six parts of the Book of ASTM Standards as well as those in the six 1950 and six 1951 Supplements. The standards are catalogued under suitable key words, and use is made of "see also" references so that the specifications are cross-referenced in as many subject fields as are applicable and important.

The Index to Standards has two basic uses: first, to determine whether or not the Society has issued any specifications, tests, or definitions on a particular material or subject; and, secondly, to note where the standards can be found.

This Index, in addition to being sent to members and committee members, goes to extensive groups of purchasing agents, Government technical officials, and others interested in the field of materials. Many members procure a few extra copies for the use of their staffs, or for distribution to key technical personnel. There is no charge for it and anyone genuinely interested in ASTM standards can have his name added to the permanent Index mailing list so that he will receive the Index as issued each year.

Another valuable contribution to the Index is the list of standards in numeric order of their serial designation, and in these lists, reference is also made to the official source of the latest publication.

Structural and Plate Steel Standards Groupings Now Available

Two special groupings of important ASTM standards have been prepared for convenient reference and use covering ASTM Specifications for Rolled Structural Steel, and Specifications for Carbon- and Alloy-Steel Plates for Boilers and Pressure Vessels.

These specifications, developed by Committee A-1 on Steel represent a limited group in two restricted fields—structural steel, and carbon and alloy plate steel.

Rolled Structural Steel:

The twelve standards included in this 41-page pamphlet cover general delivery requirements for rolled plates, shapes, and bars; bridge, building, locomotive, ship, rivet, high-strength rivet, and low-alloy structural steels; low and intermediate tensile strength carbon-steel plates; low and intermediate tensile strength carbon-silicon plates for machine parts and general construction; steel sheet piling; and the 1952 revision of specifications for structural nickel steel.

Designations covering these are as follows:

A-6	A-113	A-242
A-7	A-131	A-283
A-8	A-141	A-284
A-94	A-195	A-328

Copies can be obtained from ASTM Headquarters for $1.

Carbon- and Alloy-Steel Plates for Boilers and Pressure Vessels:

This compilation of 15 standards covers general requirements for delivery of rolled steel plates of flange and firebox qualities; boiler and firebox steel for locomotives and open-hearth iron plates of flange quality; pressure vessel carbon-silicon, chromium-manganese-silicon, nickel, molybdenum, manganese-vanadium, and manganese-molybdenum alloys.

Designations are as follows:

A-20	A-203	A-299
A-30	A-204	A-300
A-129	A-212	A-301
A-201	A-225	A-302
A-202	A-285	A-353

Copies of this 52-page pamphlet can be obtained from ASTM Headquarters for $1.50.

Soils Publications at Combination Price

Members will be interested in knowing that the five publications issued by the Society in the soils field are to be available at a special combination price of $9.75 list, $8.35 to members. The titles of the books with list and members' prices are given below:

	List	*Members*
Soil Testing Procedures (July, 1950)	$3.75	$2.80 (paper)
	4.40	3.45 (cloth)
Identification and Classification of Soils—STP 113 (April, 1951)	1.65	1.25
Triaxial Testing of Soils and Bituminous Mixtures—STP 106 (November, 1951)	3.50	2.60
Surface and Subsurface Reconnaissance—STP 122 (May, 1952)	3.00	2.25
Consolidation Testing of Soils—STP 126 (Summer, 1952)	1.75	1.35
Packet of all five books	9.75	8.35

All of these books are available with the exception of Consolidation Testing. Combination orders are being received with the understanding that this symposium will be shipped later in the Summer when it is published.

IT'S YOUR ASTM—HELP IT GROW!

1952 is a good year to invite someone to join the Society because:

1. **It is our 50th Anniversary year.**
2. **The value of membership is at an all-time high—more publications, more data coming through.**
3. **Every week emphasizes the desirability, and in fact almost the necessity of keeping in close touch with latest information on a wide range of materials, particularly with respect to evaluation of their properties.**
4. **ASTM Standards, termed by current members the backbone of industrial production, and a daily aid, should be "a first in the files of every industrialist."**
5. **Our Membership Committee will be very appreciative if our members who have done so much in previous years will be particularly alert this year.**

Nitrogen Content and Low-Temperature Brittleness of Steel

A recent investigation by the National Bureau of Standards on the effect of nitrogen on the brittleness of 0.3 per cent carbon steels at low temperatures indicates that nitrogen present as aluminum nitride lowers the transition temperature. However, nitrogen in the form of iron or manganese nitrides has an opposite effect.

The samples of 0.3 per cent carbon steel contained 0.9 to 1.6 per cent manganese, 0.2 to 0.3 per cent silicon, and variable nitrogen. One series of samples consisted of aluminum-treated steel. Impact tests showed the aluminum-treated steels to have transition temperature of approximately −110 to −140 F, whereas the nonaluminum-treated steels had transition temperatures of approximately −50 to −60 F.

This study is given in detail in the *Journal of Research* of the National Bureau of Standards as follows: G. W. Geil, N. L. Carwile, and T. G. Digges, "Influence of Nitrogen on the Notch Toughness at Low Temperatures of Heat-Treated 0.3 Per Cent Carbon Steel," Vol. 48, March, 1952.

ASTM Publications to Be Released During the Coming Months

(Late Spring and Summer)

Compilations:

- Rolled Structural Steel
- Carbon- and Alloy-Steel Plates for Boilers and Pressure Vessels
- C-1 Compilation—Cement
- D-9 Compilation—Electrical Insulating Materials
- D-20 Compilation—Plastics

Symposiums and Technical Publications:

- Symposium on Flame Photometry
- Symposium on Consolidation Testing of Soils
- Symposium on Surface and Subsurface Reconnaissance
- Symposium on Statistical Aspects of Fatigue

Special Publications:

- 50 Year Index of ASTM Publications

Successful District Meetings Held

Officers at San Francisco, Los Angeles, Richland, Washington, Milwaukee, and Detroit; Over 800 at Detroit Session on "Power from the Atom"

ON THEIR March swing to the West Coast, President T. S. Fuller and the late Executive Secretary C. L. Warwick, spoke at meetings sponsored by the Northern and Southern California Districts. Then Mr. Fuller, on invitation from a group of engineers on the atomic energy project at Richland, Wash., largely members of the American Society for Metals, addressed a meeting there on Thursday, March 27, 1952.

On April 28, President Fuller was the dinner speaker at the meeting sponsored by the Detroit District. There were about 350 at the dinner, and over 800 at the ensuing technical session, which included a panel of experts discussing "Power from the Atom." Reference also should be made to the first ASTM meeting in Milwaukee, Wis., on March 12 at the Milwaukee Engineering Society Building, held jointly with the local section of The American Society of Mechanical Engineers.

Attendance at the several meetings was high. In Milwaukee the auditorium overflowed with more than 100 present, and President Fuller advises there was an excellent crowd at the Washington meeting. Attendance in San Francisco and Los Angeles, where the local sections of the American Institute of Electrical Engineers cooperated, was not large, but the audience was representative and interested.

Various members of the Society cooperated in arrangements for these meetings. In Milwaukee Harry G. Miller, formerly Mechanical Engineer of the Chicago, Milwaukee, St. Paul & Pacific Railroad, now retired, sparkplugged the meeting as a member of the Board of Directors, in cooperation with the ASME local officers. The district officers in Northern and Southern California worked efficiently for their meetings. In Northern California, Messrs. O'Leary, Garin, Hoopes, Dresser, and others were responsible, and in Southern California Messrs. Wakeman, Niesley, Delmonte, and others handled arrangements. In Detroit, the Chairman and Secretary, Messrs. Fraser and Kennedy, handled various matters. Mr. Robert Sergeson took care of the promotion, mailing of notices, received dinner reservations, etc. Mr. R. Ward handled the arrangements for the Richland, Wash., meeting.

All of these meetings were interesting ones and afforded our members and guests an opportunity to meet the officers. President Fuller gave his talk "Solving Problems in Materials," and Mr. Warwick, in San Francisco and Los Angeles, covered "European Aspects of Standardization and Testing of Materials."

President Fuller also gave his district message at the Hanford Works in Richland, Wash. But at Detroit, after a tribute to Mr. Warwick by the District Chairman, W. R. Fraser, Mr. Fuller spoke briefly about various phases of the Society's work, including the Society's building expansion program and 50th Anniversary Meeting.

Further notes will appear on the Detroit meeting.

ISO Meetings in New York in June

A GENERAL session of the International Organization for Standardization (ISO) will be held in New York City in June, 1952. In conjunction therewith will be meetings of a number of the ISO committees and the following are the committee meetings in which ASTM has an interest:

Iron and Steel

American participation in the work of ISO/TC 17 on Steel is on the basis of an observer and is handled through ASTM Committee A-1 on Steel. The secretariat for this ISO committee is held by Great Britain. Meetings of the committee will extend through June 9–12 and the following subjects are to be considered:

Brinell Hardness Testing
Rockwell Hardness Testing
Vickers Hardness Testing
Charpy Impact Testing

Petroleum Products

Sectional Committee Z11 on Petroleum Products and Lubricants, for which ASTM is sponsor, is handling the secretariat for this ISO/TC 28 on Petroleum Products as well as the matter of American participation. The American Petroleum Institute has raised funds to support the work of the secretariat for one year and a group set up under that organization will function in the handling of the actual details of the secretariat.

June 12–14 are the dates for the meetings of this ISO Committee.

Textiles

While no meeting will be held this June of the main ISO/TC 38 on Textiles, there will be meetings of the subcommittees on shrinkage of fabrics in washing, and on yarn testing, as well as the working group on cloth strength testing using the grab technique.

The general secretariat for ISO/TC 38 has been assigned to Great Britain but America holds the secretariat for several subcommittees such as the subcommittee on yarn testing. American participation in the work of ISO/TC 38 is being handled by a special committee organized in the American Standards Assn. under the sponsorship of ASTM and the American Association of Textile Chemists and Colorists, with representation from the various groups interested; this committee has been given the designation "L23."

The meetings of the above subcommittees and working group will be held between June 12 and 16.

Mica

Subcommittee IX on Mica of ASTM Committee D-9 on Electrical Insulating Materials has been set up to handle the American contacts with this ISO/TC 56 on Mica for which India holds the secretariat. The American delegation to the forthcoming meetings (June 9–11) will consist of members of Subcommittee IX.

It is hoped that agreement can be reached at the meetings with respect to standards for mica which have been before the committee for several years.

Lac

Following the meetings of the ISO and in connection with the ASTM Annual Meeting, there are scheduled for June 23–25 meetings of ISO/TC 50 on Lac. The secretariat for this ISO Committee is held by India, and American participation is handled through Subcommittee XIII on Shellac of ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products. Members of Subcommittee XIII will constitute the American delegation to the June meetings.

Several standards for shellac have been circulated in the ISO Committee and consideration will be given to the comments submitted by the members with respect to the standards.

Many of those attending these ISO meetings will remain for the 50th Anniversary Meeting of ASTM. Several of the leading foreign engineers have been appointed official delegates of their groups at the ASTM meetings. A partial listing of these organizations appears in this BULLETIN.

ASTM Bulletin

MAY 1952

NO. 182

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

A Brief Tribute and a Call

How frequently in the loss of an intimate friend or close collaborator one gropes for words and expressions which might convey a true sense of loss and constitute some measure of appreciation for the departed! How difficult it then is to find words with which to pay homage to our late Executive Secretary.

The sudden and tragic death of C. Laurence Warwick on April 23 at the conclusion of an evening devoted to honoring our retiring Treasurer, was and is such a shock that many of our hearts are too filled with grief to record adequate tribute.

Here was a man whose whole life had been devoted to the cause of the Society, for the past 33 years as its Chief Administrative head, and for ten years prior thereto as a part-time assistant to our first Secretary, Dr. Edgar Marburg. In a sense, the tremendous outpouring of messages of sympathy received by his family and by the Society, the presence at his funeral of so many friends and ASTM associates, including many Past-Presidents and other officers, are indicative of the great esteem in which he was held.

There are hundreds of us who found real satisfaction—and how important that is in this life—in working with him in furthering of our great aims in ASTM. He, too, derived tremendous satisfaction and pleasure from his work. Certainly no one was more devoted or contributed more of himself to a cause than he did on behalf of the Society.

Perhaps the stature and reputation of this organization, established just 50 years ago, in which many of us have had a part, but in most phases of which his indelible imprint was left, is one of the finest tributes to him.

There is just so much that comes to mind, and yet it is difficult to record even this brief message. Our Fiftieth Anniversary Meeting would have meant so much to him. What a poignant statement that is. The entire meeting in a sense is a memorial to him.

The editors of this BULLETIN, who with their associates were more intimately associated with "CLW," as he was also affectionately known, have on earlier pages outlined some of his activities and given expression to some of their feelings. And later, we shall have more to say concerning his devoted life.

Speaking for the Staff as well as for your Board, I want to express appreciation to the hundreds of members who have been in touch with us. Universally, in addition to the expressions of sorrow and condolence, has been the phrase "If there is anything that I can do, be sure to call on me." We would not be true to the heritage which Larry left if we did not carry forward as aggressively and intensively as we know how the very many activities that constitute ASTM. Many of a you will be called on to assist in a somewhat special manner.

We, both the Board and Staff, know how you will respond, and that is heartening. We can be sure that in doing our part we are paying homage to one whose whole life was the Society.

T. S. Fuller

Many References to ASTM in Technical and Business Press

THE FIRST batch of clippings received by our recently reinstituted clipping service contract indicates there are many and varied references to the Society in the technical and business press. Headquarters receives a good many of these journals, which are reviewed by Staff members, and hence there is always a steadily accumulating file of tear sheets with references to the Society. The diversity of these references was not brought home strikingly until we received this combined group of clippings. References and notes on the Society range from public purchasing in 1951, field tests for paints, common sense approach to flammability problems, etc., to a legal decision where a judge assessed damages because certain types of masonry units were below ASTM standards. We were interested in the report of a British metal-finishing productivity team discussing British and American practices, which noted that among the factors which in certain respects places the American building trade in a more favorably situated position than the British counterpart was the wide scope of the work and publications of the ASTM.

Because of the importance of the work of the Society in the field of materials, it would be expected that the business and technical journals would bring to their readers pertinent news of those phases of respective interest. The service we are using, primarily to build up a file of references to the 50th Anniversary Meeting which later will be prepared in an anniversary reference file, confirmed again the realization that ASTM technical work and Society activities, especially of technical committees, really make news.

Until such time as a successor to Mr. Warwick is elected by the Board of Directors, which is now taking steps to fill this office, the Administrative Staff is carrying forward the operations of the Society under direction of the Assistant Executive Secretary, R. E. Hess, who has been empowered by the Board to exercise the duties, responsibilities, and authority of the Executive Secretary.

T. S. FULLER
President

ASTM 50 Years Ago

A Prominent "Railroader" Writes on Ethics of Testing

At the afternoon session on steel held during the Fifth Annual Meeting of the Society (1902), Paul Kreuzpointner, Engineer of Tests, Pennsylvania Railroad, deviated from the regular pattern of technical papers by reading one on the subject of "The Ethics of Testing." Since ethics in industry and government are now in the forefront, at least in the news, the words of Mr. Kreuzpointner may have a particular pertinency:

"...In work requiring purely mechanical skill, the result can be measured by rule and compass, and these are tangible quantities. In testing, however, the results may be accepted in good faith, and the man's integrity becomes a leading factor of the reliability of the work performed, because no one can measure or caliper the result. Thus, clearly, testing is largely a question of man's ethics. However scientifically correct and commercially acceptable specifications may be, their intrinsic value to the consumer is largely determined by the degree of reliability with which the final work of testing is performed.

"Because of this factor of ethics playing such a prominent part in determining commercial value of the science of testing, it is neither scientifically correct nor commercially judicious to consider the work of testing of low commercial value, to be performed by any man of average intelligence, who is willing to accept low pay. And, the closer the minimum and maximum limits of the specifications are drawn, the more complicated the work and method of testing is, the more this holds good. The properties and qualities of metals are not such fixed, unalterable quantities as not to be susceptible to a greater or less change, according to the will, knowledge, or ignorance of the operator of the testing machine, or those in charge of testing, and therefore no amount of mechanical or automatic devices will make up for any possible absence of ethics from a testing room."

ASTM 25 Years Ago

Standardization Survey—Research Fund

Ex-President Herbert Hoover, still active on problems affecting our American economic life, provided a footnote to the history of standardization when as Secretary of Commerce in 1927 he organized a Committee on Standardization Survey. The Committee under Hoover's chairmanship was made up of industrial executives, and the presidents of several engineering societies. J. H. Gibboney, President of ASTM, then Chief Chemist, Norfolk and Western Railway Co., accepted membership in the group and offered the full cooperation of the Society. The committee was organized to study the status of national standardization with a view to establishing the facts and laying them before the industries of the country so that a program of national standardization could be decided upon that would receive general industrial support.

ASTM Research Fund Started

The Directors (then Executive Committee) at the meeting in January, 1927, created the ASTM Research Fund by investing $1000 (approximately the amount of the entrance fees received in 1926) in such a Fund, and further suggested that a portion of the entrance fee be allocated each year to build up this Fund. Since then by additions from entrance fees and contributions which have been received from members and others, the fund has grown to upward of $50,000. While this is not a large sum, the income from it is carefully allocated, and on a number of occasions has enabled some outstanding pieces of research work to be completed.

District Members Will Receive Ballots on Council Elections

In May, each ASTM member and committee member in the respective ASTM Districts will receive from Headquarters a ballot on the election of Council Officers and District Councilors. This is in line with the Charter for Districts, which provides that a Nominating Committee of five members is to be appointed by the District Chairman, with Council approval. The immediate Past-Chairman normally heads the Nominating Committee, and serving with him is one Councilor, plus three noncouncilors from the district.

These Nominating Committees have been meeting and preparing their recommendations, and the nominees will be incorporated in the letter ballot. Provision is made on the ballot for writing in additional names for Council membership.

Officers (consisting of Chairman, Vice-Chairman, and Secretary) are elected in the even-numbered years, and serve for a term of two years. The terms of councilors are staggered so that about half expire each year. Only Councilors, whose terms expire, are elected in the odd years.

All ballots are to be returned to the District Secretary, full instructions being given with the ballot.

1952 Standards Seminar

John Gaillard, mechanical engineer on the staff of the American Standards Association and lecturer in industrial standardization at Columbia University, will hold his next 10-session seminar for men in industry from June 23 through 27 in the Engineering Societies Building, 29 W. 39th St., New York City.

These seminars were started in 1947 at the request of companies for assistance in the organization of their standardization work and in training of their men in writing standards specifications.

Places can be reserved now and further details may be obtained by writing to John Gaillard at 400 W. 118th St., New York 27, N. Y.

Increase in Sustaining Memberships

Sustaining Memberships in the Society now total 255. There has been a very favorable recent reaction to this class of affiliation on the part of our larger company members, 14 transfers having been effected since the beginning of the year. The seven companies most recently authorizing such transfer follow:

- Columbia-Geneva Steel Division, United States Steel Co., C. H. Fitzwilson, Chief Metallurgical Engineer
- Illinois Central Railroad Co., C. R. McEwen, Engineer of Tests
- National Research Council of Canada, Robert F. Legget, Director of the Division of Building Research
- Newport News Shipbuilding and Dry Dock Co., J. C. Jones, Chief Metallurgist
- Quaker State Oil Refining Corp., E. E. Ebner, Refinery Superintendent
- Reynolds Metals Co., Raymond B. Smith, Metallurgist, Technical Service Dept.
- West Penn Power Co., Michael D. Baker, Chief Chemist

The Board of Directors of the Society is most appreciative of the support of its Sustaining Members. A booklet describing Sustaining Membership will be sent to any organization interested.

Many Schools and Faculty Men Are Members of ASTM

Engineering Professors Play Important Part in Society Work

PROBABLY every engineering student is "exposed" to one or more courses on the properties and testing of materials, the number and extent of such courses varying with the particular curriculum—civil or mechanical or chemical, and also depending on the policies and objectives of a particular school. Many of these courses are concentrated in special departments such as "Applied Mechanics." Just recently we noted with much interest the establishment at the University of Michigan of a degree of "B.S. in Materials Engineering."

It is logical, in view of the emphasis on materials, particularly in our current economy, that many of the leading schools and technical institutes should be members of ASTM; and a considerable number of outstanding faculty men, actively concerned with materials, are participating in our committee work.

Yet always the Society officers feel that every engineering school and faculty should somehow be in touch with the work of the Society. Membership has many advantages for the professor and also for the student—the extensive publications furnished, the opportunity to keep in touch with latest developments in testing materials, and of getting reliable data on their properties are

Engineering School and College Membership in ASTM

School	Individual	Other[1]
Alabama College	1	0
Alabama Polytechnic Institute	0	1
Alabama, University of	2	2
Alaska, University of	0	1
Antioch College	0	1
Arizona University of	0	1
Arkansas, University of	0	1
Brown University	0	1
Bucknell University	0	1
California Institute of Technology	1	1
California, University of	9	4
Canisius College	0	1
Carnegie Institute of Technology	1	3
Case Institute of Technology	2	0
Catholic University	0	1
Chattanooga, University of	0	1
Cincinnati, University of	0	2
Clarkson College of Technology	0	1
Clemson Agricultural College	0	2
Colorado A and M College	0	1
Columbia University	1	1
Colorado, University of	2	1
Colorado School of Mines	0	1
Connecticut, University of	2	0
Cooper Union	1	1
Cornell University	6	2
Dartmouth College	1	0
Dayton, University of	1	0
Delaware, University of	0	1
Detroit Institute of Technology	1	0
Detroit, University of	0	1
Drexel Institute of Technology	0	1
Duke University	0	1
Fenn College	0	2
Florida, University of	1	2
Georgia Institute of Technology	2	1
Harvard University	3	0
Houston, University of	0	1
Idaho, University of	1	0
Illinois Institute of Technology	1	1
Illinois, University of	28	2
Indiana University	0	1
Institute Paper Chemistry	0	1
Institute Textile Technology	0	1
Iowa State College	7	0
Iowa, State University of	0	1
Johns Hopkins University	3	0
Kansas State—Agriculture and Applied Science	0	2
Kansas, University of	0	1
Kentucky, University of	0	1
Lafayette College	0	1
Lehigh University	1	1
Long Beach City College	0	1
Louisiana Polytechnic Institute	0	1
Louisiana State University	0	1
Louisville, University of	2	1
Lowell Textile Institute	4	0
Maine, University of	0	1
Manhattan College	2	1
Marquette University	1	1
Maryland, University of	0	1
Massachusetts Institute of Technology	10	2
Michigan State College	0	2
Michigan, University of	11	3
Minnesota, University of	5	3
Missouri, University of	0	2
Missouri School of Mines & Metallury	1	0
Montana School of Mines	0	1
Montana State College	0	1
Nebraska, University of	4	0
Nevada, University of	1	0
New Hampshire, University of	2	1
New Mexico A. & M College	1	1
New Mexico, University of	3	1
New York, City College of	3	1
New York State College of Ceramics	1	1
New York University	1	1
Notre Dame, University of	0	1
North Carolina State College	2	3
North Carolina, University of	0	1
North Dakota, University of	0	1
Northeastern University	2	1
Northwestern University	4	1
Ohio Northern University	0	1
Ohio State University	9	3
Oklahoma A. & M.	0	1
Oklahoma, University of	0	1
Oregon State College	2	1
Parks College of Aeronautical Technology	0	1
Pennsylvania State College	7	2
Pennsylvania, University of	3	0
Philadelphia Textile Institute	0	1
Pittsburgh, University of	0	1
Prairie View College	1	0
Princeton University	6	1
Purdue University	5	2
Rensselaer Polytechnic Institute	4	1
Rhode Island School of Design	0	1
Rhode Island, University of	0	1
Rochester Institute of Technology	0	1
Rose Polytechnic Institute	1	0
Rutgers University	2	3
Santa Clara, University of	0	1
St. Joseph's College (Indiana)	1	0
Seattle University	2	0
South Dakota State College	1	1
Southern California, University of	0	1
South Carolina State A. & M. College	0	1
South Dakota State School of Mines	0	1
South Carolina, University of	3	1
Southern Illinois University	0	1
Southern Methodist University	0	1
Stanford University	3	1
Stevens Institute of Technology	0	1
Swarthmore College	0	1
Syracuse University	0	1
Temple University	0	2
Tennessee, University of	1	1
Texas A. & M.	2	2
Texas, University of	1	1
Toledo, University of	2	0
Tri-State College	1	0
Tufts College	0	2
Tulane University	0	1
Tulsa University	0	1
Union College	3	0
Utah State Agricultural College	0	1
Utah, University of	1	1
Valparaiso University	1	0
Vanderbilt University	1	0
Vermont, University of	0	1
Virginia Military Institute	0	1
Virginia Polytechnic Institute	1	1
Virginia, University of	0	1
Washington State College	0	1
Washington University (St. Louis)	2	0
Washington, University of	0	1
Wayne University	1	1
West Virginia University	2	0
Western Michigan College	0	1
Wisconsin, University of	7	1
Worcester Polytechnic Institute	0	1
Wyoming, University of	1	1
Yale University	3	1
Canada		
Alberta, University of	2	1
British Columbia, University of	1	1
Ecole Polytechnique	0	1
Laval University	1	0
Manitoba, University of	0	1
McGill University	0	1
McMaster University	1	0
New Brunswick, University of	1	0
Nova Scotia Technical College	0	1
Queen's University	0	1
Royal Military College of Canada	0	1
Saskatchewan, University of	1	1
Toronto, University of	0	1

[1] Library, College Department, etc.

ample justification for the feeling on the part of some of our people that ASTM is a "must" organization for those concerned with materials.

The accompanying table gives data on the engineering school and college memberships in the Society, and for this purpose two classifications are given—the "Individual" or personal memberships, and "Other"—this column representing the university department, library, or similar unit. Actually in the Society's rules all of these memberships come in the one classification, the same dues applying for an institutional as for a personal membership.

This tabulation is presented now, in part because the Society's Committee on Membership, headed by Claire S. Fellows, is making a survey of the representation in the Society, and has suggested that all of the ASTM members on engineering school faculties might assist the committee by the submission of the names of their associates or friends at their own and other institutions who should benefit from personal affiliation with the Society. It is felt that many additional engineering schools should be represented in the Society's membership.

The accompanying list should also be of interest to many of our members who would like to know about the total representation of their own schools in the Society. Should any member have any suggestions in connection with the activity of his school in ASTM, the Membership Committee or Headquarters Staff will be glad to hear from him.

Society and Committee Officers from Engineering Schools:

It is not the purpose of this article to indicate how really widespread has been the participation of engineering professors in the Society nor to attempt to evaluate the important, constructive influence of these men on ASTM work. A general statement is in order that many engineering professors have participated very actively in the work and as stated above, are now participating and doing a great deal to advance the Society's activities involving both standardization and research in materials. Beginning with the very first Honorary Member listed in our records, Henry M. Howe, for many years Professor of Metallurgy at Columbia University, there are seven Honorary Members whose primary professional activities involve the field of engineering education; and two of these men, Thomas R. Lawson, of Rensselaer, and Herbert F. Moore, of the University of Illinois, are still with us.* Professor Lawson's affiliation dates from 1907, and Professor Moore's from 1903.

Likewise a review of the Past-Presidents of ASTM would indicate many faculty members in the list. Several of the Edgar Marburg Lecturers have been engineering professors, and the current list of officers of the ASTM technical committees, those groups which are really the heart of the Society, includes many men who are in the field of engineering education.

It may be of interest to note that apparently the school which has the longest record of continuous membership in the Society is Tufts College Engineering School, with the original date of membership 1904. Worcester Polytechnic Institute followed closely in 1905; Cornell and the University of Kansas joined the following year, and Rensselaer Polytechnic Institute became affiliated in 1907.

With respect to individual memberships, the University of Illinois currently leads the list with 28, the next highest being the University of Michigan with 11, followed closely by Massachusetts Institute of Technology, University of California, Ohio State, Iowa State, and the Universities of Pennsylvania and Wisconsin.

Finally the editors insert a "factor of safety" statement that while it is believed all of the schools in the United States (and its possessions) and in Canada represented in the membership are listed, it is possible the survey may have missed some one or more institutions. We would be very glad to be reminded if any such omissions are noted; we believe the table is reasonably reliable but cannot guarantee its accuracy.

Publications in the Engineering School:

At the recent meeting of the Membership Committee the Directors noted with interest the widespread use of the Special Compilation of Standards for Students in Engineering which so many schools use in laboratory and related courses. A number of the other ASTM publications are quite widely used too. Reduced prices apply on all ASTM books which schools may wish to use, these usually being half the list price. Further to aid the engineering student, the Society has a liberal publication policy in effect for student members, and they may request either the so-called "Student Compilation" or procure at a very nominal cost any one of the more expensive Special Compilations. The Staff will be glad to furnish members or any faculty men further details.

* Word was received as this issue went to press of the recent death of W. K. Hatt of Purdue, an Honorary Member who had been with the Society since its organization (as the American Section of the International Assn).

Schedule of ASTM Meetings

(A great many of the Society's committees will be meeting during the Annual Meeting. Complete schedule of these meetings will be distributed, as customary, by the respective secretaries. There is no combined advance list of these June meetings.)

Date	Group	Place
June 5–6	Committee B-4 on Electrical Heating, Resistance, and Related Alloys	Atlantic City, N. J.
June 23–27	ASTM Annual Meeting—Fiftieth Anniversary (Exhibit of Testing Apparatus and Laboratory Supplies, and Photographic Exhibit)	New York, N. Y.
September 10–11	ASTM Sessions, Centennial of Engineering	Chicago, Ill.
1953		
March 2–6	ASTM Spring Meeting	Detroit, Mich.
June 29–July 3	ASTM Annual Meeting	Atlantic City, N. J.
1954		
March 1–5	ASTM Spring Meeting	Washington, D. C.
June 14–18	ASTM Annual Meeting; Exhibits	Chicago, Ill.

A CRITICAL DEFENSE METALS PROBLEM MERITS YOUR STUDY

Critical Nickel Situation Discussed at ODM-ASTM Meeting

Diversified Representation, Including Other Interested Societies; Study Conservation Measures and Arrangements Needing Immediate Investigation

AT THE request of the Office of Defense Mobilization a day's meeting on the conservation of nickel was held March 11, 1952, at the Headquarters of the American Society for Testing Materials. This type of conference is one of the methods which ASTM will use to fullfill the provisions of the ODM-ASTM contract recently signed. J. R. Townsend, of the Office of Defense Mobilization presided, with the American Society for Testing Materials represented by chairmen and secretaries of seven product committees primarily interested, and three members of the Headquarters Staff. The Society of Automotive Engineers designated five to represent its interests, and four of the principal American manufacturers of jet and gas turbine engines were represented as well as the National Advisory Committee on Aeronautics. Attendance reached a total of 29.

In his opening remarks Mr. Townsend, Consultant on Conservation of Materials to the Director of the Office of Defense Mobilization, explained in considerable detail the philosophy leading to the arrangement recently made between ODM and ASTM. He then outlined the general responsibilities of ASTM under this arrangement as follows: (1) the compilation and organization of pertinent factual knowledge and reliable opinion and (2) the indoctrination of industry with the problem faced and ways and means for its solution.

In using ASTM as a center for committee organization and action there are available for assistance all of its widely diversified committees, its approximately 7000 members, and a great number of companies, both large and small, represented in the ASTM membership.

ASTM will make available through its publications, or otherwise, factual knowledge, reliable opinion, and pertinent data. It is believed that this will be used by the interests primarily concerned, with their background of knowledge relating to the manufacture and utilization of products in individual fields.

Under no circumstances will ASTM recommend or directly advise. It will not, in any sense of the word, order anybody to do anything. It will not recommend to any Governmental Department or Agency action or procedure that should or should not be taken.

If requested by the Director of ODM, pertinent information could be made available to him as an expression of informed opinion from ASTM committees. This information would not be used as the basis for issuing any orders. The Director of ODM at his discretion may request that DPA or NPA, or both, review a specific problem in a comprehensive way with industry and reach the conclusion justified in the light of available facts.

This work is being undertaken to assure an adequate supply of the materials required for the current partial mobilization and at the same time provide for full mobilization in the event that should ever become necessary. To accomplish this objective there must be an adequate national stock pile. At the same time it must be constantly kept in mind that civilian economy should be disturbed as little as practicable.

Copies of Complete Minutes of Meeting Available

IF YOU wish a copy of the complete minutes of the March 11 meeting on nickel conservation, use the coupon below or write ASTM Headquarters.

ASTM Headquarters
1916 Race Street
Philadelphia 3, Pa.

Please send me a complementary copy of the nickel conference minutes abstracted in the May ASTM BULLETIN.

Name..............................

Position or Department.............

Company..........................

Address...........................

....

This undertaking is of such breadth and importance that it should have the benefit of the best informed talent in their respective fields "across the board."

Appraising the present situation among the critical materials it appeared that nickel should be the material investigated first because of its unique properties, its wide usage in industry, and its relatively limited availability.

Nickel has the unique property of very substantially increasing the mechanical strength characteristics and corrosion resistance of iron and steel and other alloys. Its resistance to the effects of high temperature on the strength and other important characteristics of many materials is well known. Its improvement of the magnetic characteristics of magnetic materials, both hard and soft, is also well known. Its properties as a plating material and as a base for plating other metals are outstanding. The relation between its availability, usage, and stock pile supply make the conservation of nickel imperative.

The most effective conservation is provided by employing the unique properties of materials in the best possible way. In the case of metals one method would be to use the least amount of material that would consistently provide the properties that are desired, or by the process of cladding for example.

The conference emphasized the importance of the following items:

In the event of a national emergency the supply of nickel is grossly inadequate. Accordingly, a project should be initiated at the earliest possible date for developing materials that would satisfactorily replace nickel alloys in as many applications as practicable.

Electronic tubes, for communication and many other applications, are of outstanding strategic importance and are required in great quantities. At least 8 to 10 months are now required to produce and determine the satisfactoriness of material for the manufacture of electron tube cathodes. Accordingly steps should be immediately undertaken to assure there is available at all times an adequate supply of acceptable cathode material in the event of an emergency, by having qualified heats of metal in reserve.

In the light of present knowledge concerning the characteristics of materials for applications involving simultaneous exposure to flame and high mechanical stresses, and assuring the minimum distortion of parts, the necessity for substantial amounts of nickel was indicated.

Nickel is being conserved in a number of applications by replacing nickel or high nickel alloys with others having substantially less or no nickel. The substitute materials have proved satisfactory as regards both fabrication and service performance.

There should be a reappraisal of the operating temperatures and the sustained and intermittent loadings occurring in jet and gas turbine type engines to provide reliable design data to assure the most effective application of materials.

Facilities for testing are apparently inadequate for the present jet and gas turbine engine program. The effectiveness of the use of those testing facilities should be appraised. There was frequent reference to the time required for testing, and intervals as great as two to three years between initial development tests and shop production were mentioned.

There are materials that will provide adequate strengths for use in jet and gas turbine engines containing much less nickel than at present. The present processes do not permit their commercial production in quantity. Work on the production of these promising substitute materials should be continued most aggressively.

The use of alternate or substitute materials might be substantially increased if the practice of listing, on blueprints, satisfactory alternate materials for individual parts was more extensively applied.

It would be particularly helpful if there was available detailed information concerning the preferred or recommended usages of strategic materials, frequently referred to, said to have been established by the Department of Defense for the guidance of manufacturers of aircraft engines.

The conference disclosed that at least the following materials are being used satisfactorily or are being actively considered in many applications to reduce the consumption of nickel. In addition it was reported that a number of research programs are in progress for developing substitute materials to accomplish this objective.

Areas in urgent need of research were recognized.

Specific items disclosed during the discussion by ASTM committee chairmen were:

1. Boron treated steel used for pinions and ring gears.
2. Vanadium steel for heavy duty automotive axles.
3. Magnesium cast iron requires additional development to provide satisfactory substitute material.
4. Believed incentive system would substantially benefit scrap metal collection program. More judicious—effective—use of materials required.
5. Many applications for condenser tubing with reduced nickel and substantial iron content.
6. Expand process of "cladding" and application of clad materials such as nickel clad, aluminum clad, and nickel-plated steel.
7. Substitution of other elements for nickel in coinage suggested.
8. Reduced nickel content in heating element alloys.
9. Substitution of 12 per cent for 18 per cent nickel silver in sheet, rod, and tube.
10. Investigate application of copper-nickel-silicide, copper-aluminum-nickel silicide alloys, and copper nickel phosphide alloys.
11. Extend use of nickel-plated materials in production and handling of alkalies and caustic.
12. More extensive use of nickel plating.
13. More extensive use of copper-chrome and white brass sequences.

Other important measures disclosed during discussion by jet engine and automotive engineers were:

1. Actively investigate possibilities for conserving nickel by precision methods of forging and casting of high-temperature elements in gas turbines.
2. Low-carbon steels, aluminum paint protected and nickel plated.
3. Satisfactory substitution of 16 per cent chromium steel for 18-8 stainless types.
4. Substitution of type 321 steel for type 347.
5. Successful application of aluminum clad steel for combustion tubes and combustion tube liners and with limited success for tail cones and frames.
6. Make available wider selection of warehouse stocks and the substituted grades of material.
7. Encourage to fullest extent scrap conservation.
8. Encourage use of centrifugal cast and rolled flanges and contoured forgings.
9. Type 43B10 boron-treated steel satisfactory for gears.
10. Improve rough to finished weight ratio frequently running as high as 5 to 1.
11. Expand researches on methods for combining metals and ceramics, and the development of commercial processes for quality production of high-temperature materials.
12. Improve reliability of design information.
13. Manganese-nickel alloys and manganese nickel austenitic steels in satisfactory use for internal combustion engine exhaust valves.

Calendar of Other Society Events

"Long" and "short" calendars will appear in alternate BULLETINS. The "short" calendar notes meetings in the few immediate weeks ahead—the "long" calendar for months ahead.

SOCIETY OF AUTOMOTIVE ENGINEERS—June 1–6, Summer Meeting, Ambassador and Ritz Carlton Hotels, Atlantic City, N. J.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION—June 9–21, Triennial Meeting, Columbia University, New York, N. Y.

OAK RIDGE INSTITUTE OF NUCLEAR STUDIES—June 9–July 4, Course of Using Radioisotopes in Research, Oak Ridge, Tenn.

AMERICAN CHEMICAL SOCIETY—June 11–13, Joint symposium with American Physics Society, Notre Dame University, South Bend, Ind.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—June 15–19, Semi-annual meeting, Sheraton-Gibson Hotel, Cincinnati, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—June 16–18, Semi-annual Meeting, Essex and Sussex Hotel, Spring Lake, N. J.

ELECTROPLATERS SOCIETY—June 16–20, Chicago, Ill.

AMERICAN SOCIETY OF CIVIL ENGINEERS—June 16–20, Denver, Colo.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—June 19–21, Applied Mechanics Division Conference, The Pennsylvania State College, State College, Pa.

AMERICAN CHEMICAL SOCIETY—June 20–21, 5th Summer Symposium on Analytical Chemistry, Michigan State College, East Lansing, Mich.

MANUFACTURING CHEMISTS ASSOCIATION—June 23–24, Annual Meeting, Greenbrier Hotel, White Sulphur Springs, W. Va.

FOREST PRODUCTS RESEARCH SOCIETY—June 23–25, Sixth Annual National Meeting, Schroeder Hotel, Milwaukee, Wis.

American Society for Testing Materials—June 23–27, 50th Anniversary Meeting, Hotels Statler and New Yorker, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—June 23–27, Summer General Meeting, Hotel Nicollet, Minneapolis, Minn.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION—June 23–27, Annual Meeting, Dartmouth College.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—June 23–27, Oil and Gas Power Division Conference, Hotel Statler, Buffalo, N. Y.

MANUFACTURING CHEMISTS' ASSOCIATION—June 23–July 4, Annual Meeting, White Sulphur Springs, W. Va.

AMERICAN INSTITUTE OF ARCHITECTS—June 24, 25, 26, and 27, 84th Convention, Waldorf-Astoria, New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—June 28–July 2, Semi-annual Meeting, Hotel New Statler, Los Angeles, Calif.

More Unsolved Problems

Additional Research Projects from ASTM Committees

With this, the fourth issue of the Bulletin to appear this year, the publication of research problems submitted by the technical committees of the Society passes the halfway mark. The statements of these unsolved problems were submitted by the technical committees of the Society in response to a request from the Administrative Committee on Research. At the time ACR made its request, the technical committees were asked to submit typical problems rather than all of their problems. The publication of these problems has been well received and the Administrative Committee on Research is planning to ask the various committees for all additional problems that may be existent within the ASTM technical committee framework.

"Some Unsolved Problems" Now Available:

Five problems from varied fields were published in each of the first three issues of the Bulletin for this year and three additional problems are included with this article.

It was indicated in the January Bulletin that the 32 problems submitted to date by the various committees would be collected and published in a separate pamphlet. This has been done and copies of this pamphlet, "Some Unsolved Problems," are available upon request to Society Headquarters, 1916 Race St., Philadelphia 3, Pa.

The problems published in the January, February, and April Bulletin included:

- Durability of Concrete
- Constitution of Lignin
- Test for Rapid Appraisal of Weatherability of Asphalts
- Fatigue Strengths of Metals Subjected to Combined Stresses
- Effect of Various Factors on the Fatigue Life of Materials
- Particle Size of Hydrated Limes
- Can Mortar Properties Be Improved by More Thorough Mixing?
- Non-Destructive Tests for Wood
- Temperature and Humidity Measurements on Asphaltic Roofing Materials
- Study of Crack Genesis and Growth in Steel
- Rheological Properties of Aqueous Suspensions
- Chemical Reactions of Aggregate in Concrete
- Grading of Stone Sand for Masonry Mortars
- Evaluation of Fatigue-Notch-Sensitivity Index
- Fatigue Properties of Fully Hardened Steels

This issue includes:

- Prediction of Concrete Quality from Vibration Frequency and Velocity Measurements
- The Analysis of Fresh Mortars
- Relation Between Stress History and Fatigue Damage

Prediction of Concrete Quality from Vibration Frequency and Velocity Measurements

Statement of Unsolved Problem Contributed by Committee C-9 on Concrete and Concrete Aggregates

Problem:

The velocity of a sound through concrete can be measured by equipment now available. This velocity is related to the Young's modulus of the concrete and is also affected by discontinuities such as internal cracks. Since Young's modulus is related to such quality features as compressive and flexural strength, the determination of wave velocity can be of value in determining nondestructively the adequacy of concrete in place in structures. However, many variables, such as aggregate type and concrete moisture content, influence this relationship. These variables need to be isolated and evaluated in order that proper cognizance may be taken of their effect in predictions of quality.

Present State of Knowledge:

It is well established that deterioration in flexural strength due to freezing and thawing and change in Young's modulus (dynamic) are closely related. This relationship has been shown to be approximately

$$Y = 6X^{0.6}$$

where:

Y = percentage change in flexural strength

and

X = percentage change in dynamic modulus

From this relationship, measurements made from time to time on a given concrete can be compared to each other.

A small amount of information is available relating velocity or natural frequency measurements to concrete strengths.

Questions That Need to Be Answered:

1. Determination of the effects of the many variables involved in concrete on the relationship between dynamic properties and strength.
2. Determination of the effect of type and dimensions of cracks in concrete on dynamic properties.
3. Development, if possible, of simplified equipment and methods for field dynamic determinations.

Introductory References:

(1) F. B. Hornibrook, "Application of Sonic Method to Freezing and Thawing Studies of Concrete," ASTM Bulletin No. 101, December, 1939, p. 5.

(2) P. B. Kirmser, "The Effect of Discontinuities on the Natural Frequency of Beams," *Proceedings*, Am. Soc. Testing Mats., Vol. 44, p. 897 (1944).

(3) J. P. Leslie and W. F. Cheesman, "An Ultrasonic Method of Studying Deterioration and Cracking in Concrete Structures," *Journal*, Am. Concrete Inst., September, 1949.

(4) Bartlett G. Long, Henry J. Kurtz, and Thomas A. Sandenaw, "An Instrument and a Technic for Field Determination of the Modulus of Elasticity, and Flexural Strength of Concrete (Pavements)," *Journal*, Am. Concrete Inst., January, 1945.

(5) H. H. Munger, "The Influence of the Durability of Aggregate Upon the Durability of the Resulting Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 42, p. 787 (1942).

(6) L. Obert and W. I. Duvall, "Discussion of Dynamic Methods of Testing Concrete with Suggestions for Standardization," *Proceedings*, Am. Soc. Testing Mats., Vol. 41, p. 1053 (1941).

(7) Gerald Pickett, "Equations for Computing Elastic Constants from Flexural and Torsional Resonant Frequencies of Vibration of Prisms and Cylinders," *Proceedings*, Am. Soc. Testing Mats., Vol. 45, p. 846 (1945).

(8) F. V. Reagel, "Freezing and Thawing Tests of Concrete," *Proceedings*, Highway Research Board, Vol. 20, p. 587 (1940).

(9) W. T. Thomson, "Measuring Changes in Physical Properties of Concrete by the Dynamic Method," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1113 (1940).

(10) Gerald Pickett, "Dynamic Testing of Pavements," *Journal*, Am. Concrete Inst., April, 1945.

Additional information may be obtained from Kenneth B. Woods, Purdue University, Civil Engineering Bldg., W. Lafayette, Ind.

Analysis of Fresh Mortars

Statement of Unsolved Problem Contributed by Committee C-12 on Mortars for Unit Masonry

Problem:

To improve a method proposed for the analysis of fresh mortars.

Present State of Knowledge:

A method has been proposed which ef-

fects separation of the bulk of cementitious material from the most of the sand, followed by drying and suspension in a liquid which will permit centrifugal separation of lime and cement.

Questions That Need to Be Answered:

What improvements are necessary to make this method more easily applicable in the field, using the simplest equipment that can readily be transported in a suitcase, and power from a car battery for drying?

Introductory References:

(1) "Proposed Method for Analyzing Fresh Mortar," ASTM BULLETIN, No. 154, October, 1948, p. 21.

Additional information may be obtained from J. M. Hardesty, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

Relation Between Stress History and Fatigue Damage

Statement of Unsolved Problem Contributed by Committee E-9 on Fatigue

Problem:

The data contained in the conventional *S-N* diagram obtained from fatigue tests under constant stress amplitude do not express the changing characteristics of the metal induced by overstressing, understressing, or rest periods that are inherent in the normal stress history of a machine part. Information is needed to determine the effect of fluctuations in stress amplitude on the fatigue life of a member. This problem is closely associated with the need for basic information leading to a knowledge of what constitutes fatigue damage in members subjected to a variable stress history.

Present State of Knowledge:

Present design practices assume that repetitions of a stress below the fatigue limit of the material develop no damage, whereas repetitions of a stress above the endurance limit develop damage in proportion to the number of cycles of the overstress (that is, the damage is assumed to be equal to n/N, where n is the number of cycles of stress imposed, and N is the number of repetitions of stress to the normal *S-N* diagram at that stress level). However, the available data indicate that: (*a*) the fatigue limit may be markedly altered by a previous stress history, (*b*) the proportionate damage is not a simple linear function of the cycle ratio, (*c*) repetitions of stress below the original endurance limit may cause damage if the previous stress history includes repeated overstressing, and (*d*) by repeatedly stressing just below the fatigue limit and periodically increasing the load by a small increment after a large number of stress cycles at each increment (called "coaxing"), the life at the higher stress levels may be prolonged far beyond that predicted by the ordinary *S-N* curve.

Questions That Need to Be Answered:

1. What is the mechanism that constitutes fatigue damage?

2. Why is it that fatigue damage in steel does not accumulate as rapidly at a given level of stress if the member is subjected to "coaxing" (with relatively small stress increments and a large number of cycles at each of the successively increasing stresses)?

3. How can the fatigue life of a member subjected to a variable stress history be predicted from the data obtained in conventional laboratory tests?

Introductory References:

(1) J. B. Kommers, "The Effect of Overstress in Fatigue on the Endurance Life of Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 46, pp. 532–543 (1945).

(2) J. A. Bennett, "A Study of the Damaging Effect of Fatigue Stressing of X4130 Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 46, pp. 693–711 (1946).

(3) N. A. Miner, "Cumulative Damage in Fatigue," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 67, pp. A159–A164 (1945).

(4) F. E. Richart, Jr., and N. M. Newmark, "An Hypothesis for the Determination of Cumulative Damage in Fatigue," *Proceedings*, Am. Soc. Testing Mats., Vol. 48, pp. 7–67 (1948).

(5) T. J. Dolan, F. E. Richart, Jr., and C. E. Work, "The Influence of Fluctuations in Stress Amplitude on the Fatigue of Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 49, pp. 646–682 (1949).

Additional information may be obtained from T. J. Dolan, Talbot Laboratory, University of Illinois, Urbana Ill.

Does Your Hardware Corrode?

Committee A-5 Hopes to Find Out; Participation Invited

[Nothing is more frustrating to a committee or subcommittee charged with the planning and carrying out of a test program than to have some well-meaning company or individual volunteer services or specimens—long after specimens have been collected or testing begun. This article is published in order that the members of the Society may be cognizant of a new corrosion testing program involving various specimens of hardware.—ED. NOTE]

SUBCOMMITTEE XVI on Hardware Tests of Committee A-5 on Corrosion of Iron and Steel is charged with field testing of hardware articles intended primarily for outdoor use. Under this classification comes a variety of items used extensively by such industries as power, telephone, telegraph, and others.

A test of hardware items was begun some 20 years ago and is still in progress. A variety of shapes and a number of coatings were included. Among the coatings tested were hot-dip zinc, hot-dip aluminum, hot-dip lead; electrodeposited zinc and cadmium; sherardized, phosphated, and calorized finishes, and other coatings. The items tested include flat plates, angles, tubular goods, various types of clamps, nipples, ells, and many other items. At the present time, three of the original five test locations are still in operation.

These tests have served a very useful purpose and have yielded interesting data. For example, the protective value of various finishes has been found to be independent of the nature of the basis metal. It is the general feeling, however, that additional information is needed at this time. One area where information is particularly sought is in the use of the newer low-alloy steels. Also, it is felt that the earlier test was not under too satisfactory statistical control from the standpoint of uniformity of coating thickness. This showed up rather vividly in some samples supposedly having identical finishes but which behaved radically differently on exposure.

For this reason, Subcommittee XVI is contemplating a new series of tests intended to answer these and other questions. In general, most of the finishes used in the previous tests will be included. Plans are being made to obtain reliable thickness data by several methods, of which at least one should be nondestructive. As for the type and size of sample, it is thought to include articles of actual manufacture, although the feeling is that the shapes should be kept as simple as possible in order to facilitate thickness evaluations and the rating of progress of corrosion.

Inasmuch as the program is still in the formative stage, the working committee takes this opportunity to bring it to the attention of the readers of the BULLETIN. Anyone interested in this investigation, who may wish to engage actively in this work or may otherwise desire to assist the working committee or comment on this proposal is requested to communicate with A. Mendizza, Chairman of Subcommittee XVI of ASTM Committee A-5, Bell Telephone Laboratories, Murray Hill, N. J. The committee is particularly desirous of enlisting the eventual cooperation of suppliers of needed materials and finishes as well as those who are qualified and willing to engage in making thickness measurements. Any assistance will be appreciated.

TECHNICAL COMMITTEE NOTES

Gypsum Committee Considers Tests at Spring Meeting

THE results of a round-robin test series have shown that the proposed alcohol wash method for determining fineness below No. 100 sieve has given good consistency and uniformity of results. This was reported at the spring meeting of Committee C-11 on Gypsum held in Cleveland. However, further study on the data and analysis will be made before a recommendation is presented for a change in the present test procedure. More uniform results were also obtained in the normal consistency tests using the 150-g vicat rod and plunger. The procedure for mixing samples requires more attention however, and further work will be considered in the preparing of more explicit directions for the prescribed procedure. A proposed revision in the section on determining normal consistency of gypsum mixtures in the Standard Methods of Testing Gypsum (C 26) was accepted, which will recognize all types of aggregates.

Letter ballot acceptance was announced covering revisions of three ASTM standards which will now be presented to the Society for adoption. These accepted changes include the addition of a test method for core-treated gypsum sheathing in the Standard Methods of Testing Gypsum (C 26); the coverage of core-treated water-repellent gypsum sheathing in the Specification for Gypsum Sheathing Board (C 79); and the addition of $\frac{5}{8}$ in. board requirements in the Standard Specification for Gypsum Wallboard (C 36).

The present officers were re-elected for the ensuing two-year term: chairman, L. S. Wells, National Bureau of Standards; vice-chairman, H. F. Gardner, Certain-teed Products Corp.; secretary, L. H. Yeager, Gypsum Assn.

Shipping Containers Committee Holds Spring Meeting

INTERESTING data were presented on the correlation of simulated service test methods at the Spring Meeting of Committee D-10 on Shipping Containers, held at the Hotel Claridge, Atlantic City, N. J., on March 31–April 1. Data assembled by means of round-robin tests have shown to date that further refinement is necessary in the drop test method (D 775) and the revolving hexagonal drum method (D 782). A task group will re-study the drop test procedure, using a small group of laboratories and confining the series to a constant number of drops, using a corner drop method only. These test methods, among several others developed by the committee, are widely used in the industry and serve a definite purpose, but on the basis of data presented are more useful for checking within a laboratory and for control work. A special task group on statistical analysis recommended that a minimum of five samples was a sufficient number for the requirements of the cycle type of test. A standard order of sequence of tests was recommended consisting of the vibration, incline-impact drop, and revolving drum test, in that order with the compression test being conducted separately. The conditioning of samples has been recommended for separation into three types, namely, 73 F and 50 per cent relative humidity for nonperishable items, 35 F and 85 per cent relative humidity for perishable items, and 0 F for frozen items.

Current activity in the development of new test methods is confined to measurement of shock vibration of packaging and to a puncture resistance test for multi-wall bags. Two additional methods dealing with moisture and water-vapor resistance have been developed, one being a tentative method for determining water-vapor permeability of containers by the cycle method, now ready for committee ballot, and the other being a similar method for packages which is in preliminary form for subcommittee circulation. Several definitions dealing with car loading were considered by the nomenclature subcommittee. A list of equipment for measuring and recording shock, using G factors, is being compiled by a task group of the Subcommittee on Interior Packing. An interesting and enlightening talk was presented to this subcommittee on the properties of cushioning materials as found in extensive research at the U. S. Forest Products Laboratory.

A feature of the main meeting was presentation of two films, one bearing the title "Serving Industry Through Research," a story of laboratory procedure prepared by Packaging Research Laboratory, and the second film entitled "National Safe Transit Program," a pictorial presentation of data collected on impact recorder tests on various types of shipments as compiled by National Safe Transit Assn. Air cargo, railway express, freight, and truck shipments throughout the country were used to obtain these data, and in all cases it was pointed out that the handling phase provides the most severe conditions of impact. The officers elected for the ensuing two-year term are T. A. Carlson, chairman, U. S. Forest Products Laboratory (re-elected); Earl R. Stivers, Package Research Laboratory, vice-chairman; and J. H. Toulouse, Owens-Illinois Glass Co., secretary (re-elected). The next meeting of the committee will be in Chicago in October.

Glass Committee Works on New Standards

CONSIDERABLE activity was reported in the field of test methods for measuring physical and mechanical properties of glass and glass containers at the luncheon meeting of Committee C-14 on Glass and Glass Products held in Pittsburgh, Pa., on April 30, during the Annual Meeting of The American Ceramic Society. Methods are being reviewed for measuring thermal expansion, annealing and strain point, and softening point, and it is hoped to present proposed ASTM methods at the fall meeting of the Committee. Meanwhile, a round-robin test series will be inaugurated to establish the value of selected test methods.

A special group is studying the existing ASTM Method for Testing Flexure of Glass (C 158). It is planned to include further clarification of the significance of this test method in respect to its use as a criterion for establishing the quality of a glass. The development of an impact test method has been proposed and will be given further study.

Attention was called to the need for a change in the Tentative Method of Sampling Containers (C 224 T). A change in the time schedule noted in Table I of this method is definitely needed in order that the schedule may more truly represent industry practice.

It is planned to hold a meeting of the committee at the time of the October meeting of the Glass Division of The American Ceramic Society at Bedford Springs, Pa.

Ceramic Whitewares Group Meets in Pittsburgh

ACCEPTANCE by the committee of additional definitions of terms for ceramic whitewares was announced at a meeting of Committee C-21 on Ceramic Whiteware, held in Pittsburgh, Pa., on April 28, during the Annual Meeting of The American Ceramic Society. These terms include definitions of the various types of glaze such as mat, bright, vellum, and fritted; also, definitions for a variety of ceramics and porcelains such as steatite, alumina, zircon, mullite, and other basic materials are now available. The subcommittee is now voting on definitions of various degrees of vitreous, these being nearvitreous, semivitreous, and nonvitreous.

It was reported that three proposed tentative methods, now in letter ballot stage, will be further reviewed by the responsible subcommittee. They cover determination of true specific gravity of whiteware products, modulus of rupture of fired dry-pressed whiteware specimens at normal temperatures, and linear thermal expansion by the interferometric method.

A survey of existing autoclave test methods for determining moisture expansion has been made and the data collected will be used to prepare an ASTM method. Round-robin tests have been completed for measuring water absorption by the vacuum method and the test data will be tabulated. Several methods for evaluation of clays are being completed including the determination of free moisture, wet sieve analysis, and chemical analysis.

The Research Subcommittee announced that plans were proceeding for the presentation of a symposium at the 1952 Annual Meeting on the subject of "Test Methods for Process Control of Ceramic Whitewares." The next meeting of the committee will be during the 1952 Annual Meeting in New York City.

ABC Conference on Screw Threads

INDUSTRY is cognizant of the very outstanding accomplishments with respect to the unification of screw threads through agreements reached by America, Britain, and Canada (the ABC countries). This work is now being extended and a conference of representatives of these several countries is being held in New York City on June 2 at the instance of the ODM. Further mention of this work will appear in a later issue of the BULLETIN.

At the March meeting of ASTM Committee D-13 on Textile Materials Dr. Frederic Bonnet of the American Viscose Corp. was awarded the Harold DeWitt Smith Memorial Medal for outstanding achievement in the field of textile fiber science and utilization.

At the luncheon preceding the meeting and award were, seated left to right: S. J. Hayes, Ludlow Manufacturing and Sales Co.; W. D. Appel, National Bureau of Standards, and Chairman of D-13; Mrs. W. H. Whitcomb; Dr. Bonnet; Mrs. Bonnet; H. Wickliffe Rose, American Viscose Corp.; Mrs. Charles Bonnet; W. H. Whitcomb, Secretary of D-13. Standing left to right: J. S. Jacobs, Textile Research Institute; H. J. Ball, Lowell Textile Institute; H. F. Schiefer, North Carolina State College; W. J. Hamburger, Fabric Research Laboratories; Robert Bonnet, American Viscose Corp.; Charles Bonnet, American Cyanamid Co.; M. E. Campbell, North Carolina State College; A. G. Scroggie, E. I. du Pont de Nemours and Co.; K. L. Hertel, University of Tennessee; G. H. Hotte, A. M. Tenney Associates, Inc.; R. T. Kropf, Belding, Heminway Corticelli Co.

C-18 on Natural Building Stones Meets in Washington

THE development of simulated service tests to evaluate the durability of various types of natural building stones has not yet been accomplished to the satisfaction of the members of Committee C-18 on Natural Building Stones, which held its first meeting of the year in March in Washington, D. C. A very comprehensive research report on durability tests on domestic marbles using the gypsum test (ASTM C 218 T) pointed out that this test alone does not give the full answer and that further basic scientific research is necessary in order to establish the relation of structural characteristics of building stone. A special report on research at Mellon Institute, sponsored by the National Association of Marble Producers, indicated that the significance of the test results using the gypsum test was that the data can be used in estimating the bulk density changes in marble and would be of value in separating sugaring from nonsugaring marbles. Further basic research will be continued at Mellon Institute, and an outline of the proposed work will be submitted to the committee.

Certain definitions were agreed upon for letter ballot approval, including definitions of soapstone and flagstone. It was agreed that the Dale system of classification of grain size of commercial granites seemed an acceptable basis of identification. A revision for immediate adoption in the Standard Method of Testing for Modulus of Rupture of Natural Building Stone (C 99) was accepted, which will re-define the size and shape of specimens and a shortened span length. An extension of time was requested by the groups which are considering specifications for granite and roofing slate as well as for marble. It was suggested that Committee C-18 develop standards on the cleaning of building stones.

The present officers were re-elected for the ensuing two-year term: L. W. Currier, U. S. Geological Survey, Department of Interior, as Chairman; T. I. Coe, American Institute of Architects, Vice-Chairman; and F. S. Eaton, Research and Design Institute, as Secretary.

Symposium on the Chemistry of Cements

AN International Symposium on the Chemistry of Cements will be held at the Royal Institution of Great Britain in London from Sept. 15 to 20, 1952, under the sponsorship of the Department of Scientific and Industrial Research and the Cement and Concrete Assn. of England. All interested persons are invited to attend. Information can be obtained through the Secretary of the Symposium, 52 Grosvenor Gardens, London S.W.I., or R. H. Bogue, National Bureau of Standards, Washington, D. C.

E-12 Holds Symposium on Color Difference Specification

During the recent Spring Meeting of ASTM in Cleveland a Symposium on Color Difference Specification, sponsored by ASTM Committee E-12 on Appearance, was held. Two points of view were apparent. One says, "There is no unique relationship between perceptibility and the acceptability of small color differences. Therefore, since acceptability varies anyway, why not use units of the internationally adopted C.I.E. method in specifying color differences?" The other says, "Color differences are seen by an observer, and to avoid confusion between the difference itself and the scales on which it is expressed, it should be expressed in terms of scales that are as uniformly spaced for color appearance as it is feasible to get them."

In arranging the program it was felt that before discussing these points of view, it would be useful to provide the audience with a few reference points by reviewing a number of practical problems relating to the specification of small color differences and some of the methods being used to solve them, and only then to consider the more philosophical points of view. The program was arranged on such a basis, the morning session consisting of five papers summarized as follows.

Specification of Color Tolerance for Carpet Wools

H. R. Davidson, General Aniline & Film Corp., and Elaine Friede, Alexander Smith, Inc.

A total of 8000 observations on 300 samples and 20 standards were made by 9 qualified observers. Each observer stated whether or not the samples were acceptable matches for the standards. Colorimetric measurements were made and results were plotted around the appropriate standard in C.I.E. color space. Ellipsoids were then drawn around each standard in such a manner as to include as nearly as possible all samples considered to be acceptable matches with the standard in 50 per cent of the observations made and to exclude all other samples. The ellipsoids so determined were found to have radius vectors of about 2½ times those of the MacAdam ellipses in the chromaticity plane, and to have a radius vector of about 0.15 Munsell value unit parallel to the Y axis.

Color differences between standards and samples were calculated from the McAdam ellipses and also by means of the Adam's color difference formula. These measurements were then plotted against the degree of acceptability of the samples. Excellent correlation was found for measurements based on the McAdam ellipses, and poorer correlation was found for measurements based on the Adam's formula.

On the average, it was found that a color difference accepted in half of the observations will be accepted in all observations made by 30 per cent of the observers, and the remaining 40 per cent of observers will accept or reject in 50 per cent of their observations.

This experiment also showed that about two or three times the least perceptible difference was accepted regardless of the nature of the difference. In other words, there was no average tendency for observers to accept larger color differences in one color attribute than in another.

On the basis of this and other experimental work, the authors recommend color difference calculations based on the McAdam ellipses for use in color tolerance specification.

Small Color Differences in the Plastic Industry

L. Rudick and G. W. Ingle, Monsanto Chemical Co.

There is need in plastics manufacture for both intra- and inter-plant color control based on numerically defined standards and tolerances, especially for products made on a mass scale in many colors. This paper describes a system in which color differences are indicated as proportions of previously determined tolerances set up as some multiple of MacAdam's dimensions for just noticeable differences, and when needed can be readily computed in terms of MacAdam units.

The method is based on readings on a tristimulus type electronic colorimeter sufficiently basic, rapid, and understandable to be handled and interpreted without difficulty by nontechnical personnel.

A molded chip of stated thickness, or a film of known gage, is presented to the instrument for measurements. Provision must be made to either neutralize differences due to gloss or texture or to position the samples reproducibly. The X, Y, Z tristimulus values of the colorimeter are read, and then converted to C.I.E. chromaticity coordinates by application of conversion equations derived from a knowledge of the transmission filters and photocell response characteristics of the particular instrument used. The point representing any given sample is then plotted in three-dimensional C.I.E. color space.

Tolerances are plotted concentric with MacAdam's ellipses, using data from accumulated physical "limit" specimens to indicate the ellipse size. The position of the sample point with respect to the previously plotted standard point and tolerance ellipses determines immediately whether the sample in question is to be accepted or rejected, and how it differs colorimetrically from the standard.

This technique of plotting production data continuously with respect to previously established colorimetric tolerances records not only process performance, but also visual perceptibility of variation between sample and standard in terms of MacAdams small color difference units. Additionally, the limiting ellipses, determined through experience, provide an excellent picture of customer acceptability in all directions from the standard.

Colored Glass Specifications with Single Number Tolerances

N. J. Kreidl and T. G. Pett, Bausch & Lomb Optical Co.

Modern production techniques require that the ophthalmic industry exert a close control of its colored ophthalmic glasses. Older specifications in terms of dominant wave length and transmission have been found to be lopsided when evaluated in terms of perceptible color differences. Adjusted specifications have been written accommodating the perception factor. The Hunter Color and Color-Difference Meter has been found to evaluate color differences quickly and correlates well with color differences determined from spectrophotometric curves. Specifications for color can be written in terms of a given color plus or minus a given tolerance expressed as a single number.

Industrial Color Tolerance Specifications

G. L. Buc, American Cyanamid Co., Calco Chemical Div.

Various producers and consumers have used different methods of specifying color tolerances. A survey of the field indicates that visual comparisons of sample and standard in which a mental impression of the allowable deviation of the sample from the standard is compared with the actual deviation is the commonest type of specification. There is, however, a growing history of a codification of mentally retained tolerances into numerically expressed tolerances. A number of such systems are in satisfactory use in industry, yet no overwhelming tendency has been discerned to adopt any particular system for expressing tolerances about a central standard. An exhibit in a variety of materials showed color differences of the sort discussed.

Work of Group 4, Subcommittee 10 of D-1 on Industrial Reproducibility

Francis Scofield, National Paint, Varnish, and Lacquer Association

On a basis of measurements of several carefully prepared blue panels showing small color differences, as measured by several laboratories using the Hunter Reflectometer, this subcommittee reports remarkably good inter-laboratory agreement. The color series was limited, but it does seem as if reproducibility of color-difference data might be easier to obtain than reproducibility measurements of color itself.

The afternoon session consisted of the following two reports, active discussion from the floor, and a summary of the days work by Dr. Judd.

On the Specification of Color Differences by C. I. E. Coordinates

Daniel Smith, Interchemical Corp.

There is no unique relationship between perceptibility and acceptability of small color differences.

Ordinarily the acceptability of a color difference is intimately related to the particular product, its intended application, and the environment under which the product is expected to fulfill its intended function. From the purely psychological point of view, these considerations should suffice to define adequately the volume in color space enveloping a standard color in which all acceptable colors will exist.

This approach to the specification of acceptability, however, is based on the assumption that all colors are equally available. Very frequently the process of reproduction imposes limitations in the colors available, and in these cases acceptability must be tempered by availability.

These basic considerations of desirability, perceptibility, acceptability, and availability indicate that the small color differences which may finally be established as the tolerances for acceptability will not be related simply to equal perceptibility in all directions in color space.

The fundamental data locating a color in color space are adequately represented by the C.I.E. system, without implication of availability or acceptability. To transform these fundamental data to another coordinate system would serve no useful purpose because the envelope of any color tolerance specification would not be represented by simplified geometry in this coordinate system.

First Principles in the Expression of Color Differences

SIDNEY M. NEWHALL, Eastman Kodak Co.

Measurements and specifications are expressed for many purposes; in engineering, one purpose may be to represent a standard or to exhibit a tolerance. Whatever the purpose the measurement must be expressed in terms of the variable interest or some sufficiently close correlate because otherwise the purpose cannot be accomplished. In color appearance, the measurement must be expressed in terms of color appearance, or a sufficiently close correlate which may take the form of a carefully constructed color scale or system. To the extent feasible, uniformly graduated scales are preferable to warped or otherwise distorted devices. This is a general principle, and unless it is followed the representation may be too inaccurate, or its interpretation may be too confused, to be useful. If sufficiently uniform color scaling is not used to express tolerance limits about a given aim point, the tolerance is likely to be confounded with the scaling and so result in misunderstanding.

There are often various technical reasons why the application of a desirable principle, such as uniform spacing, may not seem feasible or may not be feasible without compromise. This is to be expected and perhaps this always will be the case. But the principle of uniform color spacing is sufficiently important to warrant an effort to provide sufficiently good scales of measurement or specification in other fields. Significant improvements in the color scalings of standard systems seem inevitable in the future. In the meantime, there are available compromise procedures which afford some of the advantages of uniform scaling while retaining the standard character of the C.I.E. coordinate system.

In summarizing the day's discussions, Dr. Deane B. Judd of the National Bureau of Standards, thought that considerable progress had been made in resolving the differences that seemed overwhelming at the beginning of the session.

Papers of this symposium, while not to be printed, will be made available in some form on a limited basis.

Strengthening America Through Standards

"STRENGTHENING America Through Standards" was the theme of the Second National Standardization Conference sponsored by the American Standards Association late in 1951. It also is the title of the interesting Proceedings of this conference which includes a number of significant papers dealing with aspects of this important work. The technical portion is organized in five divisions: Industrial Standards for Defense Production, Standards for Purchasing and How to Use Them, ASA Company Member Conference, Materials Conservation Forum, and Standards That Affect You and Me.

An extensive news account of this conference appeared in the December ASTM BULLETIN with abstracts and notes on some of the technical papers; however, this ASA publication covers the complete meeting and does so in an attractive style. Unquestionably, any engineer or industrialist who has responsibilities involving standards would find the material of interest and might well have a copy for handy reference right in his files. The book, with attractive heavy cover, 8½ by 11-in. page size, can be procured from the American Standards Association, 70 East 45th St., New York 17, N. Y., at $1 each.

We cannot resist a quotation and select the closing paragraph of the address, "In Standards There is Strength," by Thomas D. Jolly, Vice-President, the Aluminum Company of America and then President, American Standards Association:

> "Someone has said that there is nothing so irresistible as an idea which has found its proper time. I believe that voluntary standardization is such an idea. I believe that the standards idea has found its time, and in the hard, uncertain years ahead of us will be one of our greatest assets in winning technical advancement, prosperity, and security."

The Society Appoints....

Announcement is made of the following appointments of Society representatives

H. J. BALL, Lowell Textile Institute, on ASA Consumer Goods Committee, succeeding A. G. ASHCROFT, Alexander Smith, Inc.

MYRON PARK DAVIS, reappointed to ASA Safety Code Correlating Committee.

N. M. CLAIR, The Thompson & Lichtner Co., Inc., reappointed to ASA Building Code and Constructions Standards Correlating Committee.

F. A. PATTY, General Motors Corp., to ASA Sectional Committee Z62 on Industrial Hygiene.

W. S. YOUNG, Atlantic Refining Co., and L. E. KUENTZEL, Wyandotte Chemicals Corp., on the Joint Committee on Chemical Analysis by X-ray Diffraction Methods, succeeding RALPH O. CLARK, Gulf Research and Development Co., and VICTOR HICKS, Tracerlab, respectively.

P. G. MCVETTY, Westinghouse Electric Corp.; SAM TOUR, Sam Tour and Co., Inc.; F. D. TUEMMLER, Shell Development Co.; and L. T. WORK, Consulting Engineer, for three years, on Committee E-1 on Methods of Testing. (Reappointment)

DEAN HARVEY, Consultant on Materials, and J. W. MCBURNEY, National Bureau of Standards, as members of the Advisory Committee of Committee E-8 on Nomenclature and Definitions, for a term of three years.

CARL D. HOCKER, Union College, as a member-at-large of the Advisory Committee on Corrosion for a term of three years.

L. B. RITTER, U. S. Department of the Navy, Bureau of Yards and Docks, on ASA Sectional Committee A 95 on Applications of Gypsum Wallboard.

W. F. FAIR, Koppers Co., Inc., and K. L. HERTEL, University of Tennessee, on ASA Sectional Committee Z59 on Fluid Permeation.

L. B. JONES, Consulting Engineer, as Society representative on ASA Mechanical Standards Committee, succeeding J. R. TOWNSEND, Bell Telephone Laboratories, Inc., resigned.

A. H. SCOTT, National Bureau of Standards, as technical adviser on insulating materials to International Electrotechnical Commission.

F. E. CLARKE, U. S. Navy Engineering Experiment Station, and ROY F. WESTON, Atlantic Refining Co., to the Standard Methods Committee of the American Public Health Association.

H. F. GONNERMAN, Portland Cement Association, as ASTM representative on the General Arrangements Coordinating Committee, and Technical Program Coordinating Committee, of the 1952 Centennial of Engineering.

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

At the Spring Meeting of the American Chemical Society the following long-time ASTM'ers were among 53 ACS members honored with the presentation of 50-year membership certificates: **Herbert Abraham,** President and Chairman of the Board of Directors, Ruberoid Co., New York City; **Charles Kawin,** President, Charles C. Kawin Co., Chicago; **Fred B. Porter,** President, Southwestern Laboratories, Fort Worth Tex.; **W. P. Putnam,** retired President, Detroit Testing Laboratory; **H. E. Wiedemann,** Consulting Chemist, St. Louis, Mo.; and **James R. Withrow,** Emeritus Professor of Chemical Engineering, Ohio State University, Columbus.

Ray T. Bayless, Assistant Secretary, American Society for Metals, Cleveland, Ohio, and Editor of the ASM *Transactions,* was honored on his completion on March 1 of 30 years of service on the ASM Staff, the occasion being celebrated by a dinner attended by some of the oldtimers on the staff. Secretary **W. H. Eisenman,** who had been guiding the destinies of the fledgling organization for about three years when "Doc" Bayless arrived, was host at the dinner, and exchanged reminiscences of the early days with the guest of honor.

Robert F. Blanks has been appointed Research Consultant to the Ideal Cement Co., Denver, Colo. This appointment is in addition to his capacity as Vice-President and General Manager of Great Western Aggregates, Inc., a wholly owned subsidiary of Ideal.

D. G. Calkins, until recently on the staff of the Battelle Memorial Institute as an assistant supervisor in charge of radiochemical research, has accepted a position with the Industrial Nucleonics Corp., Columbus, Ohio. In this appointment Mr. Calkins will direct activities in the newly organized radiochemistry department of Industrial Nucleonics in developing new applications of atomic power for industry.

Otis R. Carpenter, until recently Director, Works Control Laboratory, The Babcock & Wilcox Co., Barberton, Ohio, has been appointed an Executive Assistant of the company. Mr. Carpenter has represented Babcock & Wilcox for a number of years on Committee E-7 on Non-Destructive Testing, also on the Joint AWS-ASTM Committee on Filler Metal, of which group he is currently Vice-Chairman.

Joseph G. Christ, formerly Metallurgist, Ferrotherm Co., Pittsburgh, Pa., is now on the staff of the Westinghouse Electric Co., Atomic Power Division, in a similar capacity.

Lloyd R. Cooper, formerly on the technical staff of the Heppenstall Co. at the Pittsburgh Works, is now Chief Metallurgist at the Eddystone Plant of the company.

H. J. L. Cotton has been named Technical Coordinator, Sherwin-Williams Co., Cleveland, Ohio, responsible for general supervision of technical department activities in the fields of industrial products finishes and transportation finishes.

Lyman E. Fourt has been appointed Manager of Physics Research at Harris Research Laboratories, Washington, D. C.

William A. Goodwin has been named Assistant Research Engineer, Tennessee Highway Research Program, Engineering Experiment Station, University of Tennessee, Knoxville. He previously was associated with the Kentucky Highway Material Research Lab., at Lexington.

James A. Harding, formerly Factory Manager, Modernair Corp., Oakland, Calif., is now with the Rotex Punch Co. of the same city, in a similar capacity.

Henry A. Hebley, Director of Research, Pittsburgh Consolidation Coal Co., recently was elected a Fellow of The American Society of Mechanical Engineers, the citation to Mr. Hebley honoring him for his work in the fields of atmospheric and stream pollution where, in the view of ASME, he has contributed much to the profession and "significantly to the public welfare." In ASTM Mr, Hebley has represented Pittsburgh Consolidation Coal Co. for many years, serving on numerous technical groups. He is currently participating in the activities of the recently organized ASTM Committee D-22 on Methods of Atmospheric Sampling and Analysis as representative of Bituminous Coal Research, Inc.

Gordon W. Kline, Organic and Fibrous Materials Div., National Bureau of Standards, is the recipient of the first annual Honor Award of the Washington Chapter of the American Institute of Chemists. Internationally known for his researches in organic plastics, polymerization of olefins, dopes for aircraft, and adhesives, Dr. Kline is Chairman of ASTM Committee D-20 on Plastics.

John F. Kline, formerly Manager, Pittsburgh Testing Laboratory, Milwaukee, Wis., is now Research Director, Meyer Service Co., in the same city.

Benjamin J. Lazan, Professor of Materials Engineering, Univeristy of Minnesota, has been awarded the 1951 Henry Marion Howe Medal of the American Society of Metals, presented annually to the author of the best paper published in the Society's *Transactions.* His paper appeared in Volume 42 of the *Transactions* for 1950 under the title "A Study with New Equipment of the Effects of Fatigue Stress on the Damping Capacity and Elasticity of Mild Steel."

Harry M. Moses has returned to the U. S. Bureau of Reclamation in Stockton, Calif., after several months in Washington, D. C., as a Student in the Engineering Management Training Program, U. S. Department of the Interior.

John A. Munyak, formerly on the engineering staff of Sillcocks-Miller Co., Maplewood, N. J., is now Standards Engineer, Sperry Gyroscope Co., Great Neck, L. I., N. Y.

Frederick Richard Owens has been named President and General Manager of Cyrus William Rice and Co., Inc., Pittsburgh, Pa. Until recently Mr. Owens had served as Secretary of the company. **James K. Rice,** formerly Research Engineer, has been named Vice-President and Director of Services of the company.

James S. Owens, former Executive Director of the Ohio State University Research Foundation, and previously with Dow Chemical Co. and Armstrong Cork Co., has joined Champion Spark Plug Co., Toledo, Ohio, as Assistant to the Manager of the company's Ceramic Division in Detroit.

Henry Philleo has been appointed Chief of Testing Office, Quartermaster Research and Development Labs., Jeffersonville Quartermaster Depot, Jeffersonville, Ind. Mr. Philleo recently completed a graduate course in the Ohio State University, Department of Metallurgy.

S. Gordon Saunders, formerly General Manager, Cycleweld Div., Chrysler Corp., Detroit, Mich., is now associated with Northwest Sales, Inc., of the same city.

Milton Sherman has accepted a position with Metals Refining Co., Hammond, Ind. He was previously with Silverstein & Pinsof, Inc., Chicago, Ill.

R. B. Sosman of the Department of Ceramics, Rutgers University, New Brunswick, N. J., and Chairman of Committee C-8 on Refractories, was signally honored by The American Ceramic Society at its recent annual meeting by election to honorary membership.

George E. Stryker, formerly Chief of Engineering Laboratories, Bell & Howell Co., Chicago, Ill., has been given wider responsibilities with the company as Director of the Operating Services Division. Mr. Stryker has been very active in ASTM work, particularly in connection with the Chicago District, of which Council he was Secretary and later Vice-Chairman. While John G. Heiland is taking over the representation of the company's membership in the Society, and Mr. Stryker will lighten his load somewhat in ASTM, he has indicated he is going to maintain his close interest in the Society.

John M. Thomas has been appointed Sales Manager, Resins and Chemicals Division of Jones-Dabney Co., Louisville, Ky., a division of Devoe & Raynolds Co.

Associated with Jones-Dabney for the past fifteen years, Mr. Thomas originally was employed as a laboratory assistant in the enamel production department, soon thereafter being placed in charge of the varnish development laboratory. In 1945 he became Technical Director of the Resins and Chemicals Division, and four years later was appointed Assistant Sales Manager in that same division. Mr. Thomas is active in many technical groups, concerned with paint, varnish, lacquer, and related materials.

Judson F. Vogdes, long-time member of the Society and active in Philadelphia District work where he is Past Chairman, as well as in connection with Headquarters building problems, has moved from the old Broad Street Station Building to larger offices at 34 S. 17th St., Philadelphia, Pa. "Jud" is widely known in the building materials field in this area, his consulting, design, and engineering work involving a wide range of activity.

F. Guy White, Technical Director, Granite City Steel Co., Granite City, Ill., was presented the Galvanizers' Committee third annual award for outstanding contributions to the industry during the Committee's annual meeting in St. Louis in April. Mr. White was instrumental in the founding of the Galvanizers' Committee and was named chairman at the first meeting in Pittsburgh in 1936. He has been with Granite City Steel for the past 34 years. A leader in his field, he was named Chairman of the American Conferees, Study Group 11, Galvanizing, at the World Metallurgical Congress in Detroit last October. In ASTM Mr. White serves on Committees A-1 on Steel and A-5 on Corrosion of Iron and Steel, and the St. Louis District Council.

E. D. Youmans, Vice-President in Charge of Manufacturing and Research, The Okonite Company, Passaic, N. J., has been elected to the company's Board of Directors. Well known for his activities in the electrical and rubber industries, Mr. Youmans has been on the Okonite staff since 1913.

NEW MEMBERS . . . .

The following 79 members were elected from March 17, to April 23, 1952 making the total membership 7212 . . . . . Welcome to ASTM

Note—Names are arranged alphabetically—company members first then individuals

Chicago District

Diversey Corp., The, Vladimir Dvorkovitz, Director of Laboratories, 1820 W. Roscoe, Chicago 13, Ill.

Bronson, Carlos E., Chief Mechanical Engineer, Kewanee Boiler Corp., Kewanee, Ill.

Cochran, Ray, R. Lavin and Sons, Inc., 3426 S. Kedzie Ave., Chicago 23, Ill.

Kinder, John F., Technologist, Sinclair Research Laboratories, Inc., 400 E. Blvd., Harvey, Ill.

Lund, C. V., Assistant Engineer, Chicago, Milwaukee, St. Paul and Pacific Railroad, 809 Union Station, Chicago 6, Ill.

Offutt, J. S., Merchandise Manager, Industrial, Gypsum Lime and Paper, United States Gypsum Co., 300 W. Adams St., Chicago 6, Ill.

Seaborn, G. Blaine, Plant Manager, Falk and Co., 104 Grain Exchange, Minneapolis 15, Minn.

Van Trump, Roderick, Manager, Van Trump Testing Laboratory, 329 S. Wood St., Chicago, Ill. For mail: 219 Terminal Warehouse Bldg., Little Rock, Ark.

Cleveland District

Ludowici-Celadon Co., R. H. Danison, Superintendent, New Lexington, Perry County, Ohio.

Allen, Warren W., Jr., Sales Engineer, Hydraulic-Press Brick Co., South Park, Ohio.

French, John H., Vice-President, J. C. Baxter Co., Minerva, Ohio. For mail: RD 2, Beloit, Ohio.

King, John C., Chief Engineer, Prepakt Concrete Co., Union Commerce Bldg., Cleveland 14, Ohio.

Lang, George E., Works Manager and Chief Chemist, Johnson Rubber Co., Middlefield, Ohio.

Detroit District

MacNeill, S. G., Metallurgist, Cannon-Muskegon Division of The Nugent Sand Co., Inc., Box 506, Muskegon, Mich.

Waite, C. F., Chief Chemist, King-Seeley Corp., 316 S. First St., Ann Arbor, Mich.

New England District

United Elastic Corp., S. Clark Lilley, Director of Research, 1 Cottage St., Easthampton, Mass.

Bertelsen, Bert Iver, Director of Research, Drycor Felt Co., Staffordville, Conn.

Driscoll, David E., Chief, Mechanical Test Section, Watertown Arsenal, Arsenal St., Watertown, Mass.

Howerton, W. W., Sales Manager, American Monomer Corp., 511 Lancaster St., Leominster, Mass.

Lowell Textile Inst., Lowell, Mass.

New York District

American Wax Importers and Refiners Assn., Inc., R. E. Sievert, President, 36 W. Forty-fourth St., New York, N. Y.

Bausenbach, A. E., Inc., Henry C. Meyer, Rubber Research Engineer, 19 Allen St., Buffalo, N. Y.

Pfizer, Charles, & Co., Inc., F. Howard Hedger, Director, Analytical Dept., 11 Bartlett St., Brooklyn 6, N. Y.

Bidgood, Earle S., Chief Metallurgist, Remington Rand Inc., Laboratory of Advance Research, Wilson Ave., South Norwalk, Conn.

Copson, Harry R., Head, Corrosion Section, The International Nickel Co., Inc., Box U, Bergen Point Station, Bayonne, N. J.

Fardon, Harry D., Jr., Chemist, Allied Chemical and Dye Corp., Columbia Rd., Morristown, N. J.

Keller, T. P., 42-28 203rd St., Bayside, L. I., N. Y.

Linkletter, Harry, Divisional Vice-President, International Division, Interchemical Corp., 67 W. Forty-fourth St., New York 36, N. Y.

Lockwood, George H., Manager, Chemical Processes and Services, Westinghouse Electric Corp., Arlington Ave., Bloomfield, N. J.

O'Brien, Kenneth H., Civil Engineer, Porter-Urquhart, Assn., 415 Frelinghuysen Ave., Newark 5, N. J. [J]*

Weaver, Vincent P., Assistant Metallurgist, The American Brass Co., 414 Meadow St., Waterbury 20, Conn.

Zane, Edward E., Quality Control Superintendent, Mojud Hosiery Co., Inc., 36-46 Thirty-third St., Long Island City, N. Y.

Northern California District

California State Department of Public Works, Division of Architecture, Charles M. Herd, Principal Structural Engineer, 515 Van Ness Ave., San Francisco 2, Calif.

Horonjeff, Robert, Lecturer and Research Engineer, Institute of Transportation and Traffic Engineering, University of California, Berkeley, Calif.

Morgan, Glen, Purchasing Specifications Analyst, State of California, Dept. of Finance, Purchasing Division, 107 State Office Bldg., No. 1, Sacramento, Calif.

Ohio Valley District

Finn, John, 22 E. Maplewood Ave., Dayton 5, Ohio

Miller, Robert D., Chemical Engineer, The Electric Auto-Lite Co., Sharonville, Ohio.

Richards, D. L., Chief Chemist, Carlisle Chemical Works, Inc., Reading 15, Ohio.

Philadelphia District

Adams, Leslie H., Materials Engineer, Frankford Arsenal, Pitman Dunn Laboratories, Tacony and Bridge St., Philadelphia, Pa. For mail: 4647 Naples St., Philadelphia 24, Pa.

Crawford, C. S., Executive Vice-President, The Whitehall Cement Manufacturing Co., 123 S. Broad St., Philadelphia 9, Pa.

Jones, Joseph Holton, Specification Writer, Stanhope & Manning, Architects, 902 Orange St., Wilmington 21, Del.

Reed, George, Manager, General Laboratories, American Car and Foundry Co., Ninth and Oak Sts., Berwick 6, Pa.

Sharon, B. L., Chief Metallurgist, Lycoming-Spencer Division, Avco Manufacturing Co., Plant 1, Oliver St., Williamsport 19, Pa.

Warner, Charles L., Owner, Warner Laboratories, 617 First St., Cresson, Pa.

Pittsburgh District

Bissey, L. T., Assistant Professor, Petroleum and Natural Gas Engineering, The Pennsylvania State College, Mineral Industries Bldg., State College, Pa.

Ghering, Leonard G., Director of Research, Preston Laboratories, Box 149, Butler, Pa.

O'Brien, Harold C., Jr., President, Royston Laboratories, Inc., Blawnox, Pa.

Paul, William H., Superintendent, American Chain and Cable Co., Inc., Braddock, Pa.

St. Louis District

Peck's Products Co., Louis E. Wells, Jr., Director of Research, 610 E. Clarence Ave., St. Louis, 15, Mo.

Holtgrieve, M. M., Partner, Holtgrieve and Co., 2817 Laclede, St. Louis 3, Mo.

Southern California District

Darnell Corp., Ltd., Clinton R. Bigelow, Rubber Chemist, 12000 Woodruff Ave., Downey, Calif.

California State Department of Public Works, Division of Architecture, James A. Gillem, Architect, 217 W. First St., Los Angeles, Calif.

Copeland, Ray E., Southwest Steel Rolling Mills, Box 3518, Terminal Annex, Los Angeles 54, Calif.

Washington (D. C.) District

National Plastic Products Co., The, J. Roland Brown, Director of Laboratory, Odenton, Md.

Pajak, Theodore P., Supervisor, Glenn L. Martin Co., 6713 Danville Ave., Baltimore 22, Md.

Freeman, Andrew R., Engineer, American Instrument Co., 8030 Georgia Ave., Silver

Spring Md. For mail: 7300 Fourteenth St., N. W., Washington 12, D. C. [J]

LINDSAY, JOHN T., Lieutenant, Chemical Engineer, Chemical Warfare Biological Lab., Camp Detrick, Md. For mail: 14 West Thirteenth St., Frederick, Md. [J]

Western N. Y.-Ontario District

THATCHER GLASS MANUFACTURING CO., INC., Roy S. Arrandale, Technical Director, Central Laboratory, Box 265, Elmira, N. Y.

BEINGESSNER, CLARENCE, Partner and Manager, B. & W. Precision Heat-Treating Co., 70 Borden Ave., South, Kitchener, Ont., Canada.

DE ZEEUW, CARL, Assistant Professor of Wood Technology, Department of Wood Technology, State University of New York College of Forestry, Syracuse 10, N. Y.

KELLY, POTTER W., Deputy City Engineer, Department of Engineering, 400 City Hall, Syracuse 2, N. Y.

ROGERS, PHILIP S., Senior Engineer, Harrison Radiator Division, General Motor Corp., Lockport, N. Y.

USHER, I. A., Chief Metallurgist, Canadian Steel Improvement, Ltd., Box 32, Station N., Toronto 14, Ont., Canada.

U. S. and Possessions

SLINE INDUSTRIAL PAINTERS, L. L. Sline, President, 2162 Gulf Terminal Dr., Houston 23, Tex.

CASSELL, ROBERT E., Washington Technical Laboratories, N. 209 Bernard, Spokane, Wash.

EDGE, JAMES M., Metallurgical Engineer, Sheet and Tin Mills, Tennessee Coal and Iron Division, United States Steel Co.

LUKER, J. P., Research Laboratory, General Portland Cement Co., Box 15, Houston 1, Tex.

ROSS, S. I., Chief, Design Engineering Section, U. S. Bureau of Mines, Rifle, Colo. For mail: Box 251, Rifle, Colo.

STALLARD, OTTO D., JR., Division Superintendent, Magnolia Pipe Line Co., Dallas 1, Tex.

WAITE, CALVIN L., Junior Design Engineer, Boeing Airplane Co., Box 3104, Seattle 14, Wash. For mail: 2424 E. Denny Way, Seattle 2, Wash. [J]

Other than U. S. Possessions

ELDORADO MINING AND REFINING (1944), LTD., COMMERCIAL PRODUCTS DIVISION, R. F. Errington, Manager, Box 379, Ottawa, Ont., Canada.

ESCO, LTD., D. A. Livingston, Assistant Manager, 146 E. First Ave., Vancouver 10, B. C., Canada.

FAIREY AVIATION CO., LTD., THE, W. E. Cooper, Chief Metallurgist, Hayes, Middlesex, England.

ASSOCIATION SUISSE POUR L'ESSAI DES MATÉRIAUX, A. von Zeerleder, President, Leonhardstrasse 27, Zürich, Switzerland.

DANIEL, MARIO C., Manager, Mechanical Branch, Design Div., DPWO 10th Naval District, San Juan, Puerto Rico. For Mail: Box 9027, Santurce, Puerto Rico.

HIGNETT, HAROLD WILLIAM GEORGE, Research Superintendent, The Mond Nickel Co., Ltd., Wiggin St., Birmingham 16, England.

NIKLASSON, LEIF RAOUL, Chief Oil Engineer, Central Laboratory, Malmslätt, Sweden. For mail: Alvastragatan 2B, Linköping, Sweden.

SAMUEL, DAVID LEO, Technical Adviser, Shell Petroleum Co., Ltd., Shell Court, Box 83, London E 1, England.

VOSSINIOTIS, CHRISTUS J., Director, Designs Division, Ministry of Transport, Athens, Greece. For mail: 33 Didymou St., Athens, Greece.

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* J denotes Junior Member.

NECROLOGY . . .

The death of the following members has been reported

EDWIN F. CONE, formerly editor of *Materials & Methods* (1935–1943) when it was known as *Metals and Alloys* (March 18, 1952). One of the country's distinguished journalists, Mr. Cone's career was long and outstanding. He had already reached a position of eminence as a chemist and metallurgist in the steel foundry industry before joining *The Iron Age* prior to World War I. He served *The Iron Age* as associate editor for twenty years. During World War II he served on the Washington staff of the War Metallurgy Committee. Affiliated with many technical societies, Mr. Cone was a member of ASTM for more than 18 years, serving through the years on Committees A-3 on Cast Iron, and A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. He had retired from the staff of *Materials & Methods* in 1947. With innumerable friends in all fields of his endeavors, "Doc" Cone's associates at Reinhold Publishing Co. felt he was "one of the kindest and most cheerful men every known."

HAROLD FIELDING, Textile Analyst, U. S. Customs Laboratories, New York, N. Y. Member since 1948.

J. A. HARGAN, Head, Engineering Dept., Todd-Johnson Dry Docks, Inc., New Orleans, La. (March 4, 1951). Member since 1950.

H. G. HILL, Advisory Engineer, Ehret Magnesia Manufacturing Co., New York City (April 27, 1952). Representative of his company's membership in the Society since 1938, Mr. Hill had rendered important service in Committee C-16 on Thermal Insulating Materials through the years, in several subgroups and the Executive Committee, as well as the main committee. Last year he had been named Secretary of C-16, and had given close and conscientious attention to the duties of this office, also to the extension of membership in the Society and the Committee. He had represented C-16 on Committee E-12 on Appearance for some years.

HARRY J. KELLY, retired Manager of Construction and Maintenance Division of the Manufacturing Department, Gulf Oil Corp., Pittsburgh, Pa. (January 21, 1952). Member of Research Division on Measurement and Sampling of Committee D-2 on Paint, Varnish, Lacquer, and Related Products from 1945 until his retirement in December, 1951.

G. L. LINDSAY, Director of Tests and Research, Universal Atlas Cement Co., New York City (April, 1952). Member since 1929. Well known in the cement field, Mr. Lindsay had been a member of Committee C-1 on Cement for many years, serving on the Advisory Committee, Subcommittee on Cement Reference Laboratory, and several other subgroups. He also had served on the Subcommittee on Compression Testing of Committee E-1 on Methods of Testing, as representative of C-1; and had represented the Portland Cement Assn. on the ASA Sectional Committee on Specifications and Methods of Test for Hydraulic Cements since 1948.

CHARLES ELLISON MACQUIGG, Dean, College of Engineering, The Ohio State University, and Director, Engineering Experiment Station, Columbus, Ohio (April, 1952). A leader in the field of metallurgy as well as engineering education, Dr. MacQuigg in his earlier years was with the Santa Fe Railroad and the Anaconda Copper Co. for brief periods. From 1912 to 1917 he headed the Department of Metallurgy at Pennsylvania State College. He served as Captain, Ordnance Dept., U. S. Army, in World War I; in World War II he attained the rank of Lt.-Colonel, Ordnance Department. For 18 years prior to his appointment at Ohio State in 1937 he was associated with the Union Carbide and Carbon Corp., Research and Development Laboratories. He was a member of many technical societies and the author of numerous papers. His achievements further include several metallurgical inventions. In ASTM he had been active for many years in various technical groups, representing the Union Carbide (1929–1937) on Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, and on Committee B-4 on Electrical Heating, Resistance, and Related Alloys. Later he served for some years on the Joint ASME-ASTM Committee on Effect of Temperature on the Properties of Metals, also on former Committee E-9 on Research. He was currently a member of the Ohio Valley District Council, and representative of the Ohio State Engineering Experiment Station on Committee C-21 on Ceramic Whiteware.

H. E. MALONE, Western Electric Co., Inc., Hawthorne Works, Chicago, Ill. (February 20, 1952). Representative of his company since 1945 on Committee D-1 on Paint, Varnish, Lacquer, and Related Products, serving on Subcommittees VII on Accelerated Tests for Protective Coatings, XIV on Electrometric Testing of Films, XVIII on Physical Properties of Materials, and XXV on Cellulosic Coatings and Related Materials.

JOHN J. MCINNIS, Assistant Manager, Eagle Rock Lime Co., Eagle Rock, Va. (February 28, 1952). Member since 1936, and member of Committee C-7 on Lime for the same period.

ALAN MORRIS, Director of Research, Bridgeport Brass Co., Bridgeport, Conn. (circa April 1, 1952). Representative of sustaining membership of his company since 1938, also representative of his company for many years on Committees B-2 on Non-Ferrous Metals and Alloys, and B-3 on Corrosion of Non-Ferrous Metals and Alloys.

PHILIP K. ROOS, Engineer, Applied Physics Lab., Johns Hopkins University, Silver Spring, Md. (April 1, 1952). Member since 1949.

C. LAURENCE WARWICK, Executive Secretary, American Society for Testing Materials, Philadelphia, Pa. (April 23, 1952). Member since 1912. (See article on page 5.)

NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Instrument Notes

Control Relay—A new electronic control relay, designed to operate in conjunction with a differential transformer transmitter, has been developed by Automatic Temperature Control Co. The transmitter may be one of the numerous types available, such as those for pressure, flow, motion, force, etc. To obtain control of any variable, the differential transformer is adjusted so that its zero position is at the exact point at which you desired to obtain control. This position is sensitive to less than 0.0001 in. and as the armature of the transformer is moved off this null point by a change in the variable, a signal is generated having amplitude and phase definition. The control relay is sensitive to this minute signal and either pulls in or drops out depending on the direction of the signal.

Automatic Temperature Control Co., 5200 Pulaski Ave., Philadelphia 44, Pa.

High Gain Preamplifier—Now available is a new high gain a-c preamplifier, designed to permit the extension of the measurable range of graphic recording instruments or cathode ray oscilloscope into the microvolt region and maintain a relatively flat frequency response from 0.2 to 400 cps. Designated as Model BL-954 by the manufacturer, the instrument was designed for use with Brush Magnetic Direct Writing Oscillographs and medium or low gain amplifiers to permit immediately available permanent records of measurements of electrical phenomena in the microvolt region such as brain, heart, and nerve potentials or research and industrial laboratory measurements.

The Brush Development Co., Instrument Division, 64, 3405 Perkins Ave., Cleveland 14, Ohio.

Spring Tester—A new type spring tester (patent pending) is a precision instrument for checking the loads and deflections of compression and extension springs and was designed as an accurate low-cost tester. Speed of testing varies from 300 to 600 tests per hour. Production stops and tolerance markers are easily adjustable and accuracy is guaranteed within $\frac{1}{4}$ of 1 per cent thereby meeting the requirements of the National Bureau of Standards. Capacity—loads up to 300 lb, spring diameters up to 4 in., spring lengths up to 12 in. for compression and 10 in. for extension.

The Carlson Co., 277 Broadway, New York 7, N. Y.

High Speed, High Vacuum Pump—A new vacuum pump called the "Hypervac-4" has been announced by Central Scientific Co. for use in plant, laboratory, or research process where high speed, high vacuum is a requirement. It is a two stage unit with a free air displacement of 41 liters per minute and a pumping speed at 1 micron of 0.35 liter per second. It attains an ultimate vacuum of 0.1 micron. According to the manufacturer this new unit is especially adapted to use with oil diffusion pumps due to its small size, high capacity, low ultimate vacuum, and quiet operation.

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

New Laboratory Jack—A new device is said to provide the laboratory with an all-purpose, general utility support that is light in weight, sturdy, and compact and considerably faster in action than conventional supports. Utilizing the scissors-Jack principle, the unit, called the "Lab-Jack" permits quick, accurate adjustment of height over a wide range. The range of elevation is about 7 in. and the maximum platform height is $10\frac{1}{4}$ in.

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

Chromatography Unit—A standardized chromatography unit is now available. Included in the apparatus is a stainless steel support rack to hold the strips; a glass tray and Petri dish for the solvent; glass rods for attaching and holding the strips. The entire apparatus fits into a large cylindrical Pyrex brand glass jar with an outside diameter of 12 in., an outside height of 24 in. This closure makes possible the saturated atmosphere required for optimum analyses. In use, the worker places one drop of each sample near the top of an individual paper strip and hangs the strips from the support rack. The upper edges of the strips are curled to dip into a $5\frac{1}{2}$ by 4-in. trough, and solvent is added to this trough after the jar's atmosphere has become saturated with solvent from the lower dish. When capillary action moves the solvent down the strip, components of the original drops separate vertically as individual streaks or bands.

Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

Multi-Purpose Compression Tester—Originally designed for "flat crush" tests of boxboard, a new compression tester is said to be suitable for testing a wide variety of materials and products. It makes flexure tests of plastics, glass, ceramics, insulation board, plywood, asbestos-cement shingles, and carbon-brush materials. General compression testing of springs can be performed. In the paper industry the tester is used for "flat crush" and "column compression" tests of paper and corrugated board, and compression tests of cases, drums, cartons, and containers conforming to specifications of the Technical Associaton of the Pulp and Paper Industry. Accuracy with the Tester is said to be within $\frac{1}{2}$ per cent at half capacity and within one scale division at lower loadings. There is a low range of 0 to 100 lb, and a high range of 0 to 1000 lb.

Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

New Thermometer Marking Material—A new permanent filler for lines and numbers on laboratory thermometers has been developed by Kimble Glass, division of Owens-Illinois Glass Co. The new development is said to add to the life of the laboratory thermometer and overcomes a common fault—the disappearance of markings due to the erosion of acids and organic elements. Amber in color, the new filler stands out clearly against the white and yellow backgrounds of the thermometers. To determine permanency of the fillers the new type thermometers were immersed in acids, alkalies, and organic solvents at elevated temperatures for long periods of time with no damaging effect on the filler.

Kimble Glass, Vineland, N. J.

Electronic Thickness Tester—A new electronic thickness tester for measuring thickness of electrodeposited metallic coatings has recently been announced. This new instrument measures the thickness of chromium, silver, tin, cadmium, zinc, copper, and nickel deposits on various base metals (including nonmagnetic base metals) with an average accuracy of 90–95 per cent on plane and most curved surfaces according to the manufacturer. The standard model is limited to a minimum thickness of 5 hundred-thousandths of an inch (5 millionths for chromium); the maximum thickness which can be tested is indefinite, although deposits over 2 thousandths of an inch have been tested. The operator is required only to set the instrument for the type of plating being tested and to press a button to start the test.

Kocour Co., 4806 S. St. Louis Ave., Chicago 32, Ill.

Water Purifier—A new water purifier device for making raw water chemically pure, called "Deeminac," consists of a polyethylene bottle with a specially blended filter of deionizing materials inserted in the neck like a stopper. When the container is filled with ordinary tap water, all that is required to produce a stream of chemically pure water is "one quick squeeze" of the pliable, polyethylene bottle, according to the manufacturer. Water from the unit, it is claimed, is equivalent in ionic purity to that produced by triple distillation. The special filter, which changes color when it has been consumed, is said to produce up to 20 gallons of chemically pure water depending upon local conditions. Replaceable filters are available.

E. Machlett & Son, 220 E. 23rd St., New York 10, N. Y.

Automatic Buret—A new automatic buret is specially constructed for use with a polyethylene plastic reservoir. A gentle squeeze of the bottle will fill the buret which is of the automatic zero type. A polyethylene delivery tube offers greater safety against breakage. It is being marketed as the "Royalton Press-O-Matic Buret." Available in 10 and 25-ml sizes the unit is supplied complete with reservoir.

Meyer Scientific Supply Co., Inc., of 215 N. 8th St., Brooklyn 11, N. Y.

Portable Survey Meter—A newly designed wide range beta-gamma survey meter, Model 2585, has just been announced. Based on the principle of the wartime "Cutie Pie" the new unit is said to offer many unique features. Model 2585 is so designed that it can be set upright for continuous monitoring. It is light weight, with a circuit and battery housing ahead of and close to the fingers. The five-position switch, providing zero setting and three ranges up to 5000 mr/hr, is located at the top of the pistol-grip handle to allow one-hand operation of the instrument. Zero adjust and calibrate controls are on top ahead of the 2½-in. meter which slopes toward the user for easy reading. The instrument weighs 3 lb complete with batteries.

Nuclear Instrument & Chemical Corp., 229 W. Erie St., Chicago 10, Ill.

Second Stop-Clock—A dependable, low-cost stop-clock, embodying the across-the-room visibility of a household clock, is available for laboratory use. The unit has a 36-hr movement controlled by two buttons on top: the dial is marked in seconds, and a large sweep hand permits estimations to half a second. A smaller integrating hand registers total time elapsed up to 60 minutes.

Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Spigot for Five-Gallon Cans—A new type spigot for dispensing oils, solvents, glycerine (or any other noncorrosive fluids) from five-gallon cans has been announced. According to the supplier, it is easy to install and will rapidly dispense the contents without spilling or splashing. It can be used on any size opening up to 2 in. The design also utilizes a lapped plunger which is opened by pressure on the thumb button. When the pressure is released, a strong spring halts the flow. To resist corrosion, the spigots are made of cadmium-plated copper.

Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Pipet Filling Machine—A new automatic pipet and vial filling machine which dispenses chemical and serological reagents, serums, antigens, antitoxins, biologicals, etc., said to offer high accuracy at speeds instantly variable from 10 to 90 deliveries per minute is now available from the Scientific Glass Apparatus Co. A special tip is said to prevent hanging drop. The unit, which covers the entire range from 0.025 to 50 cc. without expensive attachments, does not have to be recalibrated each time it is used. All liquid contacting parts are made of stainless steel.

Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Six-Inch Dial Indicator—A newly designed dial indicator suited for modern instrument panels and also for individual mounting has been announced. This instrument was primarily developed to meet the requirements of the temperature, pressure, and load applications in industrial processing. The 6-in. dial indicator has a high visibility dial with white graduations and numerals on a black background. Its white wedge-shaped pointer or indicator is provided with a microadjustment to permit easy and accurate zero settings. A notable feature is the new stainless steel movement which is designed to eliminate linkage errors. The design of the instrument is said to provide for almost universal actuation by any variable that makes use of a Bourdon spring as an energy-to-motion converter.

Bulletin 98214, Taylor Instrument Cos., Rochester 1, N. Y.

Catalogs and Literature

Concrete Consistency Unit—A brochure is available describing the Acrow Wigmore Consistometer for determining workability of concrete. The unit is said to perform this operation accurately and rapidly. The brochure describes the importance of knowing the workability of concrete and includes a technical description of the unit together with operating procedure.

Acrow (Engineers) Ltd., South Wharf, London W.2, England.

Filter Papers—Recently published by H. Reeve Angel & Co. is a new catalog describing the Whatman filter papers for which the firm acts as sole American Agent. Special sections of the catalog are devoted to papers for accurate gravimetric analysis; qualitative analysis (where ash weight is not important); hardened filter papers; extraction thimbles; diffusion shells for osmosis; ashless filter papers for chromatography.

H. Reeve Angel & Co., 52 Duane St., New York 7, N. Y.

Three-Dimensional Microscopes—Fully illustrated with photographs and sketches of various models and accessories, a new catalog, "Bausch & Lomb Stereomicroscopes," has been published. The series 14 models (formerly called Stereoscopic Wide Field Microscopes) provide a magnified image which is both stereoscopic and unreversed. While the instruments are best known perhaps in the fields of medicine and education for biological work and dissecting, the catalog points out that industry is "rapidly finding more and more application for these optical aids for quality control. Today, many small parts assembly operations such as bearings, watches, etc., are handled more quickly and efficiently with three-dimensional magnification."

Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.

Specimen Mount Press—New bulletin describing "AB" Speed Press. Features include use of preheated premolds, rapid closing, and universal application for thermosetting or thermoplastic materials in 3 sizes. Also available is a six-page booklet describing grinders and surfacers designed for metallurgical samples. Both belt and wheel types are offered for wet or dry grinding.

Buehler Ltd., 165 W. Wacker Dr., Chicago 1, Ill.

Inquiries concerning the "Advantages of Membership" will be welcomed during the Society's 50th Anniversary Year

To the ASTM Committee on Membership
1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in ASTM and include a membership application blank. Also related information on the 50th Anniversary Meeting.

Signed____________________
Address____________________
____

Date____________________

Industrial Filters—A new bulletin describes the Schott Narrow Band Interference Filters made by the Jena Glass Works Schott & Gen., West Germany. These filters are distributed in this country by the Fish-Schurman Corp. Separate sections of the bulletin cover the precision of location of maximum transmission; transmission and width of transmittance; filter curve characteristics as a function of tilt angle; applications; dimensions; and prices. Special information for use in ordering filters is also included.

Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N. Y.

General Laboratory Apparatus—Vol. 21, No. 4, of "The Laboratory" is now available. Among the new items described and illustrated in the 32-page pocket size journal are a new unit for fast, Karl Fischer, micro and other titrations; permanently marked thermometers; a self-zeroing buret; and a photomultiplier attachment that increases the "DU" spectrophotometer's sensitivity.

Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

General Laboratory Apparatus—Just announced in the publication of Vol. 4, No. 1, of "Lanco Apparatus News." It is an eight-page bulletin describing many new items of equipment such as the Kinney vacuum pump, electric stopwatches, aluminum speed desiccators, new filamatic automatic pipetting machine, polyethylene bottles and funnels, bacteriological incubators, air velocity meters, and many other items are illustrated and described in detail.

Arthur S. La Pine and Co., 121 W. Hubbard, Chicago 10, Ill.

Flex Tester—A recently published sheet gives information on a new unit called the "Gelbo Tester" designed to simulate the flexing conditions imposed on materials incident to handling operations. The sheet describes operation of the equipment, development of the equipment, and interpretation of results.

The Package Materials Laboratories, Inc., 461 Crescent Rd., Hatboro, Pa.

Vacuum Equipment—Research Vacuum Supply Co. have just issued a 40-page illustrated catalog listing research high-vacuum equipment, high-vacuum pumps and oils, gages, glass working machinery; including a full line of hand-fires, torches, blast burners, needlepoint burners and accessories, crossfires, and miscellaneous supplies for glass blowing.

Catalog 11 K, Research Vacuum Supply Co., 3434 W. Montrose Ave., Chicago 18, Ill.

Variable Transformer and DC Power Supply—Two new pieces of literature are available from The Superior Electric Co. Bulletin 252 describes the new type 10 "Powerstat" variable transformers. Included in the bulletin are photographs, outline dimensions, ratings, and other descriptive material. The type 10 is intended for use in a-c voltage control problems involving 5, 50, 100, and 150 w. Bulletin V1051 describes the "Varicell" d-c power supply. This unit is a source of variable stabilized-regulated d-c voltages operating from a-c power lines. Included are photographs, circuit diagrams, outline dimensions, ratings, and other descriptive data.

Superior Electric Co., Bristol, Conn.

Temperature-Sensitive Crayons—A recently prepared supplementary instruction sheet for temperature-sensitive crayons called "Tempilstiks" covers in detail the recommended use of these indicators in a variety of industrial and research applications. Applications under special environmental conditions are discussed and a number of procedures and techniques for determining temperatures are set forth. A few of the topics covered are: attained temperatures of rapidly moving pieces and rotating objects; temperature distribution and isothermal boundaries of a heated workpiece; temperature indication against a brightly radiating background; effect of strongly reducing atmospheres; effect of ionized air and electrical fields.

Tempil Corp., 132 W. 22nd St., New York 11, N. Y.

Exhibit Descriptions

(Continued from page 18)

(Electro Mechanical). The "Varicell" DC Power Supply is used in obtaining a precise, yet multiple, range of regulated and stabilized low d-c voltages. The "Voltbox" AC Power Supply provides accurate dependable variable a-c voltage.

Tagliabue Instruments Division
Weston Electrical Instrument Corp.
Booth 36

(Report on display not available at time of publication.)

Testing Machines, Inc.
Booth 61

Representatives of this firm will be on hand to outline and discuss any of the instruments of a wide range which this concern offers to the paper, steel, and textile industries. Two types of metal hardness testers will be on display along with a selected group of the latest paper and board testing instruments.

Arthur H. Thomas Company
Booth 31

Featured will be the Atlab Emulsion Test Apparatus for the examination and precise comparison of prepared emulsion formulations; a simple and inexpensive new Stopcock Tension Clip for pressure-tight seating of stopcock plugs; Magnetic Stirring Apparatus with a new type stirring bar which is sealed into Teflon and is acid and alkali resistant; Stormer Viscosimeter with Stroboscopic Timer which improves the accuracy and speed of the paint consistency test; new Beckman Aquameter for rapid, automatic titration of moisture; and Beckman Model B Spectrophotometer with Flame Attachment.

Thwing-Albert Instrument Company
Booth 37

This firm will exhibit a number of different testing instruments. Among them will be three widely varying instruments, one for the measurement of temperature, one for tension testing and one for measuring printing ink consistency. The Bolometer is a rapid action instrument for following transient temperatures at a distance. The new Electro-Hydraulic Tensile Strength Tester will be in operation on a wide range of materials from single fibers through cardboard and plastics to stove bolts. The Inkometer will indicate and record changes in printing ink film consistence while working at three different speeds.

United States Testing Company, Inc.
Booths 1, 2

The new reticles made by microphotographic methods, satisfy a need for finer lines and greater accuracy in the optical instrument field. Line widths of one micron and five microns line spacing can be mass produced by this method. These reticles are used in microscopes, collimotors, theodolites, micro balances, comparators, etc. The Terg-O-Tometer on display was made to duplicate household washing machines on a controlled laboratory basis. It is used in evaluating soaps and detergents. The Flammability Tester determines fabric flammability under standard AATCC test conditions.

Uddeholm Company of America, Inc.
Booth 7

The DISA and MICROPOL Electro Polishers (in operation) are two new instruments which have already established a reputation in rapid preparation of metallographic specimens. Combined polishing and etching cycle in 30 seconds. Simple to operate, nonsensitive. The Bergsman Micro-Hardness Tester attached to the Reichert MeF Camera Microscope, attachable to any inverted metallograph, incorporating scratch and indentation tests; no time wasted in transfers for photomicrographs. The Nobel Institute Calibration Stage Micrometer having accuracy 0.01 micron.

Wallace & Tiernan Products, Inc.
Booth 4

This firm will exhibit several models of sensitive pressure indicators of the aneroid type. Featured will be the Wallace & Tiernan Absolute Controller for accurate controlling operations in the high vacuum range. Technical personnel will be in attendance to explain performance and suggest applications.

Wilson Mechanical Instrument Division
American Chain & Cable
Booth 13

Items to be displayed are the Rockwell Hardness Tester and the Tukon Hardness Tester. The first, developed in 1921, is designed for use in measuring hardness of metals and alloy of all types: hard or soft, polished or unpolished; whether flat, round, tubular, or irregular in shape. Supplied in four models. The second, the Tukon Hardness Tester, is used in micro hardness testing and macro hardness testing with 136 deg Diamond Pyramid Indenter. Supplied in three models.

Electron Microstructure of Bainite in Steel

(Second Progress Report by Subcommittee XI of ASTM Committee E-4)*

An earlier report by this Subcommittee on the "Electron Microstructure of Steel"[1] dealt with the results obtained from the examination of a series of microstructures in plain carbon eutectoid steel. After completing the examination of isothermal transformation products, as well as a series of quenched-and-tempered structures, several interesting observations were made.

One of these was the marked difference in structure that occurs upon isothermal transformation within the bainite range between the temperatures of 500 and 950 F. Although a difference in appearance between lower bainite and upper bainite can be observed with a light microscope, the difference is much more pronounced when examined with the electron microscope.

In view of the importance of these structures, and since they are not adequately resolved by the light microscope, the committee chose, as the next phase of its work, to investigate the isothermal transformation products formed within the bainite range in more detail. It was proposed to establish the transition temperature between lower and upper bainite by examining specimens that had been completely transformed at 500, 550, 600, 650, 700, and 750 F. No higher temperatures were necessary since it had already been shown by the earlier work that lower bainite is not formed at 750 F.

It was also proposed to study partially transformed structures containing upper bainite. Such specimens would be helpful in studying the nature and mode of formation of upper bainite. Any additional information that could be obtained along these lines might shed some light on the mechanism of the transformation which takes place in this region.

Experimental Work

Following the procedure adopted for the earlier work, several sets of identical specimens were prepared in the laboratory of the U. S. Steel Co. The specimens were cut from a sample of the same steel used in the initial work and which has the composition shown:

Carbon, per cent	0.87
Manganese, per cent	0.44
Silicon, per cent	0.17
Phosphorus, per cent	0.013
Sulfur, per cent	0.006
Nickel, per cent	0.39
Chromium, per cent	0.21

All specimens were austenitized 35 min at 1800 F. This treatment produced a No. 5 ASTM austenite grain size.[2] To prevent excessive decarburization, the specimens were copper-plated prior to heat treatment, and austenitized in a reducing atmosphere. The particular heat treatment given each specimen after austenitizing is shown in Table I. The specimens examined in the earlier work, which fall within or encompass the bainite range, are also included for completeness.

Those specimens which were transformed at temperatures above 550 F were quenched from the austenitizing temperature first into a bath at 550 F. This was done to increase the cooling rate through the intermediate temperature range where the delay in onset of transformation is shortest, and thus to prevent transformation during cooling. The holding time at this temperature was sufficiently short so that it is assumed that no significant transformation occurred. After 6 sec at 550 F, the specimens were transferred to another bath at the desired temperature where they were held for a time sufficient to produce the desired amount of transformation.

Samples Nos. 17, 18, and 19 represent transformations of 20, 50, and 100 per cent, respectively. The transformation temperature selected for these partially transformed structures containing upper bainite was 850 F, since the needles of upper bainite formed in this region are relatively large and well defined. At the same time, this temperature is low enough so that little fine pearlite is formed.

The metallographic technique employed in the preparation of these specimens was[3]:

Polish—Mechanical, using customary procedure.
Etch—4 per cent picral.
Replica—Formvar or collodion negative, by direct stripping; metal shadowcast at 27 to 45 deg.
Print—Direct enlargement of micrograph negative.

Of the common etchants, picral was selected because it was found by experience to be the most satisfactory for developing uniformly the extremely fine structure found in lower bainite. The time of etching (etch depth) used depended upon the particular microstructure being examined. At least two etching times were used for each specimen in order to study the effect of etch depth on the appearance of the microstructure. The characteristics of other etchants, and their relationship to various microstructures in steel, will be discussed in detail in a forthcoming report on techniques.

Discussion

Near the lower end of the bainite temperature range at 500 F the microstructure formed upon isothermal transformation, when examined under the light microscope at 2500 ×, appears as an acicular structure consisting of mottled needles of varying shades of gray. The detail within these needles, however, is much too small to be resolved by the light microscope. Examination of this structure under the electron microscope at higher magnifications reveals that the ultimate micro-

TABLE I.—HEAT TREATMENTS TO FORM BAINITE STRUCTURES

Sample	Heat Treatment	Hardness, Rockwell C Scale
No. 5	2½ hr at 500 F	57.4
No. 13	1 hr at 550 F	56.3
No. 14	6 sec at 550 F, 30 min at 600 F	53.2
No. 15	6 sec at 550 F, 15 min at 650 F	50.4
No. 16	6 sec at 550 F, 9 min at 700 F	47.2
No. 4	6 sec at 550 F, 7 min at 750 F	43.8
No. 17	6 sec at 550 F, 12 sec at 850 F	54.3
No. 18	6 sec at 550 F, 20 sec at 850 F	42.3
No. 19	6 sec at 550 F, 2 min at 850 F	40.6
No. 3	6 sec at 550 F, 1 min at 950 F	41.0

* Members of Subcommittee XI actively participating in this study: D. M. Teague, *Chairman*, Chrysler Corp.; L. R. Cooper, *Secretary*, Heppenstall Co.; L. A. Aldinger, General Motors Corp.; L. S. Birks, Naval Research Lab.; E. J. Dofter, Chrysler Corp.; A. L. Ellis, International Harvester Co.; R. M. Fisher, United States Steel Co.; E. F. Fullam, General Electric Co.; W. L. Grube, General Motors Corp.; J. M. Hodge, United States Steel Co.; D. M. McCutcheon, Ford Motor Co.; H. C. O'Brien, Jr., Heppenstall Co.; T. G. Rochow, American Cyanamid Co.; G. E. Pellissier, United States Steel Co.; E. S. Rowland, Timken Roller Bearing Co.; C. M. Schwartz, Battelle Memorial Inst.; J. R. Vilella, United States Steel Co.

Editorial Note.—This condensation of the Report on Electron Microstructure of Bainite is presented in anticipation of the publication of the whole report which will appear complete with photomicrographs with the preprint of the Report of Committee E-4 on Metallography.

[1] "Electron Microstructure of Steel. First Progress Report of Subcommittee XI, ASTM Committee E-4 on Metallography," *Proceedings*, Am. Soc. Testing Mats., Vol. 50, p. 444 (1950).

[2] Standard Classification of Austenite Grain Size in Steels (E 19 - 46), 1949 Book of ASTM Standards, Part 1.

[3] For a more complete description see the Appendix of "Electron Microstructure of Steel," *Proceedings*, Am. Soc. Testing Mats., Vol. 50, p. 489 (1950).

structure of lower bainite is characterized by ferrite needles containing many small carbide platelets in parallel array. Within each needle these parallel platelets are oriented at an angle of approximately 55 deg with respect to the needle axis. The apparent differences in size between these platelets is largely a reflection of differences in orientation of the needles with respect to the plane of polishing.

Preliminary electron diffraction measurements made on bainite transformed at 500 F indicate that the slow-etching constituents are principally cementite, Fe_3C, although some hexagonal ϵ-iron carbide[4, 5] is present.

When the transformation takes place isothermally at 550 F, the gross appearance is very similar to that of 500 F bainite. The similarity persists when the fine structure is examined under the electron microscope at 15,000×. Like that formed at 500 F, the structure consists of ferrite needles which contain extremely minute carbide platelets arranged in a parallel array at an angle to the needle axis. The electron micrograph also shows that these particles, as in the lower temperature structure, are plate-like in shape and that most of the apparent difference in size is due to differences in orientation of the plates with respect to the surface being examined.

Preliminary electron diffraction measurements on the slow-etching microconstituents of the bainite specimens transformed at 550 F and at higher temperatures did not detect the presence of hexagonal ϵ-iron carbide. Only the diffraction lines corresponding to cementite were observed. The cross-striated needle structure characteristic of lower bainite persists in the specimens transformed at 550 and 600 F and hence it might be assumed that the platelets in these specimens are cementite. Additional measurements will be made to confirm this point.

Transformation at 600 F yields a microstructure which under the light microscope, strongly resembles that obtained at 550 F, and also under the electron microscope at 15,000× the characteristic fine structure of lower bainite still prevails.

When transformation is allowed to take place at 650 F, the marked acicular structure observed in specimens transformed at the lower temperatures has begun to disappear and only occasional needles are found. Upon examining this structure under the electron microscope at 15,000× certain structural differences are apparent.

1. The carbide particles observed in this structure tend to be larger than those in the lower temperature products. The shape of the carbide has also changed to a certain extent. Instead of the small thin platelets, long plates of carbide are found which appear in section as "stringers."

2. The major portion of the structure consists of small, irregularly shaped areas in which the carbide plates are arranged in a regular fashion. In general, the carbides within these small areas lie in a parallel or fan-shaped array which imparts a directional appearance to the area.

3. Some scattered needle-shaped areas still exist. These areas, however, constitute a minor portion of the total structure. Unlike those of lower bainite, these needles do not exhibit the characteristic 55-deg cross-striated pattern. The very thin carbide plates are still arranged in a parallel array, but are oriented in a direction more nearly parallel to the axis.

From the above observations, it is evident that the lower bainite structure has disappeared and that a transition to a different structure, although not abrupt, has taken place in the temperature range between 600 and 650 F. The microstructure has changed from predominantly needles with cross-striated platelets, to a structure with small oriented areas wherein the carbide is parallel to the longer dimension.

Increased etching brings out some of the microstructure more clearly. At 600 F the characteristic cross-striated needles of lower bainite are very evident, while at 650 F the almost complete alteration of carbide orientation is

Fig. 1.—Electron Micrograph of Upper Bainite, Structure 20 per cent Transformed at 850 F (×15,000).

[4] K. H. Jack, "Results of Further X-Ray Structural Investigation of the Iron-Carbon and Iron-Nitrogen Systems and of Related Interstitial Alloys," *Acta Cryst.*, Vol. 3, p. 392 (1950).

[5] K. H. Jack, "Structural Transformations in the Tempering of High-Carbon Martensitic Steels," *Journal of the Iron and Steel Inst.*, Vol. 169, p. 26 (1951).

visible—long carbides now parallel to the length of an area. The deeper etch increases the apparent size of the carbides.

Examination of the structure formed upon isothermal transformation at 700 F, under the light microscope at 2500 ×, provides little information concerning the size and distribution of the carbide. However, an electron micrograph of the structure of 15,000 ×, shows that most of the carbide is in the form of relatively large particles, or plates which appear as long stringers in the plane of the polished surface. Within a given area, the stringers all lie in approximately the same direction and, in most cases, are nearly parallel to the longest dimension of the area. Those areas in which the carbides appear randomly dispersed arise when a needle is sectioned transversely. The parallel array of carbide particles within a small oriented area is not satisfactorily resolved by the light microscope.

The structure formed upon isothermal transformation at 700 F strongly resembles the bainite structure formed at 750 F, which was examined previously by the committee. However, the carbide particles and length of needles are not so large as those formed at 750 F.

As stated earlier in this report, the committee proposed to investigate the nature and mode of formation of upper bainite in greater detail by examining specimens which had been partially transformed in the upper bainite temperature range. Previous work on specimens of this steel[1] transformed in this region showed that patches of upper bainite found in specimens transformed isothermally at 950 F have a feather-like appearance under the light microscope at 2500 ×. When examined under the electron microscope at higher magnifications, the branches of these "feathers" are shown to be coarse carbide plates or ribs (needles) arranged in a parallel fashion. It was also shown that much of the microstructure of specimens transformed at 950 F consists of fine pearlite.

The transformation temperature chosen for the investigation of the nature and mode of formation of upper bainite was 850 F in order to avoid possible interference by coexisting fine pearlite. Furthermore, the upper bainite structure formed at this temperature is relatively coarse and well defined. An electron micrograph of the 20 per cent transformed structure at 850 F is shown in Fig. 1. The feather-like appearance frequently observed in light micrographs is evidently a manifestation of the long parallel carbide stringers in a ferrite matrix which are clearly revealed in the electron micrograph of this structure.

As will be noted, bainite in the very early stages of transformation frequently exists as single plates (appearing as needles when sectioned). It will also be noted that the advancing transformation "front" of the bainite area appears like the point of a needle whose tip consists essentially of ferrite, with little or no carbide. There is generally a sheath of ferrite around the carbide in bainite, as illustrated by the platelet at the lower left-hand side of the micrograph. Figure 1 also shows some small needles arrested at an early stage of transformation, these small needles consisting entirely of ferrite where the plane of the polished surface has not cut through the carbide.

The microstructure of the specimen transformed 50 per cent (20 sec at 850 F) is less feathery in appearance than that in the 20 per cent transformed specimen. At this later stage in the transformation, the individual bainite areas have grown longer and considerably broader. The relatively fast rate of growth in the breadth direction and the development of smaller intersecting bainite areas probably explain why this structure appears less feathery than that of the 20 per cent transformed specimen. The plane sectioning the bainite frequently reveals a leaf-like structure, with a central rib of carbide along the axis, surrounded by radiating needles (or plates) of carbide.

An electron micrograph of the fully transformed structure is shown in Fig. 2. While some portions of a light micrograph of this structure are partially resolved, presumably, these repre-

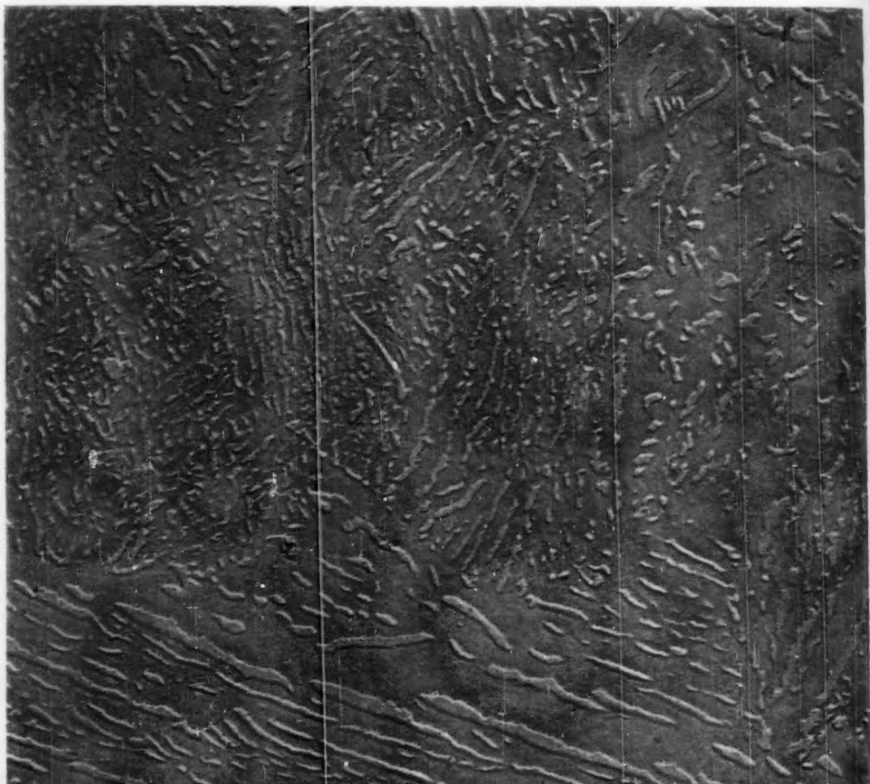


Fig. 2.—Electron Micrograph of Upper Bainite, Structure Fully Transformed at 850 F (× 15,000).

sent regions in which long carbide stringers occur, as more clearly revealed in the electron micrograph. Most of the structure, however, is not resolved by the light microscope. Under the electron microscope, on the other hand, the structure of this fully transformed 850 F bainite is seen to be very similar to that of the fully transformed structures at 650 to 750 F, except that the carbide particles are, generally, somewhat larger. The areas between the coarse carbide stringers are made up of smaller intersecting bainite structures.

Also observed are fine carbides which are arranged in a regular, somewhat parallel, fashion resembling those found in fine pearlitic structures formed at higher temperatures. It has already been shown[1] that both upper bainite and fine pearlite are formed and co-exist in structures transformed at 950 F. The appearance of fine pearlite indicates that this microstructure can be formed at temperatures as low as 850 F for this steel.

Conclusions

The results obtained from the electron metallographic examination of bainitic structures in eutectoid carbon steel lead to the following conclusions:

1. The majority of the carbides found in lower bainite are extremely small, plate-like particles arranged in parallel array within long, narrow ferrite needles. The small carbide platelets appear as cross-striations at an angle of 55 deg to the ferrite needle axis. Because of their plate-like nature, the apparent difference in size of these particles in different needles is largely due to differences in orientation.

2. Based upon the disappearance of the characteristic cross-striated needles of lower bainite, the transition from lower to upper bainite occurs in the transformation temperature range between 600 and 650 F.

3. The transition from lower to upper bainite is characterized by two distinct changes in the microstructure. First, the size, shape, and orientation of the carbide particles change from extremely small platelets arranged in parallel array at an angle of approximately 55 deg with respect to the axis of the bainite needles, to larger carbide particles and stringers arranged in more nearly parallel array. Second, the needles of ferrite which account for the marked acicular nature of lower bainite disappear. In their place appear small irregularly shaped areas in which the carbide particles and stringers are arranged in parallel fashion, with their length in the direction of the longer dimension of the area.

4. As the temperature of transformation is further increased above the transition range, the size of the individual upper bainite areas increases and the carbide stringers become larger and longer.

5. Electron micrographs of specimens partially transformed to upper bainite at 850 F show the structure to consist of stringers of carbide surrounded by a sheath of ferrite. Similarly, "feathery bainite" is a parallel array of carbide needles or plates, in a ferrite matrix.

6. In the initial stage of the transformation, individual platelets (seen as needles) are formed. As the transformation progresses, there is a relatively fast increase in breadth of these long, coarse, bainite areas.

7. Small amounts of fine pearlite can co-exist with upper bainite in this steel at transformation temperatures as low as 850 F.

Although preliminary electron diffraction indicates the presence of some hexagonal ϵ-iron carbide in bainite transformed at 500 F, the results suggest that the carbide platelets are cementite in the cross-striated needle structure in 550 and 600 F lower bainite.

Future Work

During 1952 and 1953, Subcommittee XI plans to investigate the following phases of this work on eutectoid steel more intensively:

1. The changes in microstructure which occur when bainite is tempered. Specimens of bainite will be transformed at various temperatures, then tempered under conditions comparable to those for the tempered martensite samples already studied,[1] in order to permit comparison.

2. Additional electron diffraction measurements will be made to confirm the preliminary results regarding the occurrence of ϵ-iron carbide and cementite.

3. Specimens of bainite isothermally transformed at temperatures just above the M_s temperature will be prepared. Examination of the microstructure with the electron microscope may give information about extreme lower bainite. Electron diffraction measurements of these specimens should yield data on the occurrence of ϵ-iron carbide.

4. The effect of various etchants and depths of etch on the different microstructures is being investigated and the results will be reported.

NBS Report on Fire Tests of Wood-Framed Walls

The National Bureau of Standards Report, by Nolan D. Mitchell, entitled "Fire Tests of Wood-Framed Walls and Partitions with Asbestos-Cement Facings" provides fire resistance data derived from recent tests on asbestos-cement shingles and wall facings. This information will aid building authorities and regulatory agencies in evaluating fire-resistive characteristics of wood-stud walls and partitions made of these materials, and will give the prospective builder a basis for the selection of constructions to meet specific fire-resistance requirements.

The tests are described and illustrated in the 14-page report, No. 123, in the Bureau's Building Materials and Structures Report series. Copies may be obtained from the Government Printing Office, Washington 25, D. C., for 15 cents.

Tape Resistor Developed at NBS

A new National Bureau of Standards Circular, "An Adhesive Tape-Resistor System," by B. L. Davis, describes developmental work on an adhesive tape-resistor permitting close control of resistance values, and gives detailed information on production of the resistors and on equipment and materials needed. The carbon-film resistor in the form of an adhesive tape, covers a range of 10 ohms to 10 megohms and by virtue of its use of asbestos paper tape and silicone resin binder is capable of operation up to 200 C. Because the curing temperature is high, 300 C for several hours, the tape is at present applicable only to glass or ceramic base materials.

Copies of the amply illustrated, 83-page booklet can be obtained from the Government Printing Office, Washington 25, D. C., at a cost of 30 cents.

Reviews of Petroleum Technology

Volume 11 of the Institute of Petroleum Technology's Reviews of Petroleum Technology contains a valuable and critical record of the progress made in the science and technology of petroleum during 1949. As in previous years the authors have done much searching of literature to examine the material on which their reviews are based and the volume contains references to nearly 3000 technical papers and articles.

Although 1949 is the year mainly covered, there are instances where in previous years the information available has been insufficient to warrant a review covering one year only. Thus, the present volume reviews plant instrumentation for the period 1947 to 1949, crude oils for the same period, and insulating and hydraulic and bitumen for the years 1948 and 1949.

ASTM Definitions of Terms Relating to Methods of Testing

ED. NOTE.—The importance of standardization in this field cannot be emphasized too strongly. The definitions represent basic concepts that are the concern of all materials engineers, and every effort should be made to secure information. It is for this reason that the present discussion of the subject is being published with the request for comments and suggestions. Further discussion will appear in subsequent issues of the BULLETIN.

INTRODUCTION BY P. G. MCVETTY[1]—When the Standard Definitions of Terms Relating to Methods of Testing (E 6 - 36) were developed, it was intended that these represent fundamental concepts and as such would be applicable to the various types of stresses and various materials representing the widely divergent fields covered by the Society. They have served the needs of the Society for many years. These definitions, however, have not kept pace with rapid developments in materials and test methods and there are many terms commonly used that are not included. As a result, many technical committees have found it desirable to add similar or new definitions in various specifications and methods to suit the needs of modern testing procedures.

This appearance of many scattered definitions can result in much confusion as well as duplications. It would be far preferable to correlate the various definitions and to concentrate them in one document.

The first attempt at correlation was between the Definitions E-6 and a group of definitions prepared by Committee D-20 on Plastics and published as an Appendix to the Tentative Methods for Tensile Properties of Plastics (D 638 - 49 T). These efforts resulted in revised definitions which were accepted by Committee D-20 with the understanding that acceptance also by Committee E-1 as a replacement for Definitions E 6 - 36 would allow substitution of a reference to the revised Definitions E 6 - 52 T for the Appendix to D 638 which covers 2½ pages.

The revised definitions, however, have not been accepted by Committee E-1. The reasons for the objections have been summarized by Walter Ramberg of the National Bureau of Standards. Similar objections have been received from H. L. Fry a representative of Committee A-1 on Steel, who maintains that methods of testing should not be included in Definitions E-6 and suggests that the present definitions of "yield point" and "yield strength" should be modified.

The broad problem of having adequate ASTM definitions of terms relating to methods of testing is of interest to a major portion of the Society membership. The revised definitions are accordingly being published together with Mr. Ramberg's summary of the objections to the definitions and Mr. Fry's discussion. The committee wishes to have the help of all concerned in arriving at satisfactory definitions and would very much appreciate having suggestions.

In addition to any other comments or suggestions, answers to the following three questions are solicited:

1. What terms in Definitions E 6 - 36 need to be redefined to adapt them to the needs of the ASTM as a whole, and how should the terms be defined?

2. What terms growing out of recent developments in materials and testing procedures should be added to those defined in E-6, and how should the terms be defined?

3. What definitions now given in various specifications and methods might be collected under "Standard Definitions of Terms Relating to Methods of Testing" (E-6). Suitable references could then be made to E-6 wherever such terms require definition.

Suggestions may be sent to ASTM Headquarters or to the Chairman of the Task Group.

DEFINITIONS OF TERMS AND SYMBOLS RELATING TO TENSION TESTING OF PLASTICS

(Proposed as a Revision of the Definitions Appearing in Methods D 638)[2]

DEFINITIONS

1. *Tensile Strength* is the maximum tensile load per unit area of original cross-section, within the gage boundaries, required to break a test specimen. ("Tensile load" is interpreted to mean the maximum tensile load sustained by the specimen during the test, whether or not this coincides with the tensile load at the moment of rupture.) It is expressed in pounds per square inch.

2. *True Ultimate Tensile Strength* is the tensile load required to break a test specimen, at the moment of rupture, divided by the minimum cross-sectional area of the ruptured test specimen. It is expressed in pounds per square inch.

3. *Tensile Stress* (nominal) is the tensile load per unit area of original cross-section, within the gage-boundaries, carried by the test specimen at any given moment. It is expressed in pounds per square inch.

4. *True Tensile Stress* is the tensile load per unit of minimum cross-sectional area within the gage boundaries carried by the test specimen at any given moment. It is expressed in pounds per square inch.

5. In Paragraphs 6 to 15 dealing with elongation, the gage length (measured elongation "section") should be stated. If the specimen necks down before fracture, the value of elongation recorded depends enormously on whether a short or long gage length was used in making the measurements.

6. *Extension* is the change in length produced in a uniform longitudinal section of a test specimen, measured between fixed gage points on the specimen, by a tensile load. It is expressed in inches.

7. *Strain* is the ratio of the extension to the original length of the measured elongation section of the test specimen, that is, the change in length per unit original length. It is expressed as a dimensionless ratio. (Also known as *Longitudinal Tensile Strain.*)

8. *Unit Extension* is synonymous with strain.

9. *Total Extension* is the extension recorded at the moment of rupture of the test specimen. It is the sum of the recoverable (elastic) and nonrecoverable (plastic) extension.

10. *Total Strain* is the unit extension recorded at the moment of rupture of the test specimen. The total strain is the sum of the elastic plus permanent strain.

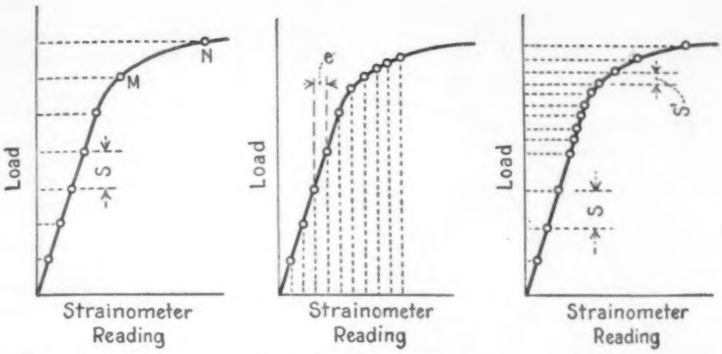
11. *Total Unit Extension* is synonymous with total strain.

12. *Percentage Elongation* is the increase in length, expressed as a percentage of the original gage length. In metals it is measured by carefully fitting together the ends of the fractured specimen. In reporting elongation values, both the percentage increase and the original gage length shall be given.

13. *Percentage Total Elongation* is the extension recorded at the moment of rupture of the specimen expressed as a per-

[1] Research Laboratories, Westinghouse Electric Corp., East Pittsburgh, Pa.; Chairman Subcommittee 3, Task Group on Review of Definitions, Committee E-1 on Methods of Testing.

[2] See Appendix to the Tentative Methods of Test for Tensile Properties of Plastics (D 638 - 49 T), 1949 Book of ASTM Standards, Part 6.



(a) With equal increments of stress. (b) With equal increments of strain. (c) With two values of increments of stress.

Fig. 1.—Illustrating Three Methods of Plotting Load-Deformation Curves.

centage of the original length of the measured elongating section. It is equal to 100 times the strain measured at the moment of rupture of the specimen.

14. *Residual Elongation* is the extension measured one minute after rupture of a tensile specimen, by fitting together of the broken ends, expressed as a percentage of the original length of the measured elongating section. The length of the measured elongating section must be stated. Example: the residual elongation in 2 in. was 00 per cent.

15. *True Strain* is found by referring the extension at any instant to the actual length at that instant, instead of to the original length L_0.

16. *Nominal Reduction of Area* is the difference between the original cross-sectional area of the test specimen and the cross-sectional area measured at the point of rupture after breaking the specimen in tension. It is expressed in square inches.

17. *Nominal Unit Reduction of Area* is the ratio of the nominal reduction in area to the original cross-sectional area of the test specimen, that is, the nominal reduction in area per unit original cross-sectional area. It is expressed as a dimensionless ratio.

18. *Nominal Percentage Reduction of Area* is the nominal reduction in area expressed as a percentage of the original cross-sectional area of the specimen. It is equal to the *Nominal Unit Reduction in Area* multiplied by one hundred.

19. *True Reduction of Area* is the difference between the original cross-sectional area of the test specimen and the minimum cross-section area within the gage boundaries at the moment of rupture in tension. It is expressed in square inches.

20. *True Unit Reduction of Area* is the ratio of the true reduction in area to the original cross-sectional area of the test specimen; that is, the true reduction in area per unit original cross-sectional area. It is expressed as a dimensionless ratio.

21. *True Percentage Reduction of Area* is the true reduction in area expressed as a percentage of the original cross-sectional area of the specimen. It is equal to the *True Unit Reduction in Area* multiplied by one hundred.

22. *Tensile Stress-Strain Curve* is the curve obtained by plotting *Tensile Stresses* as ordinates against corresponding *Longitudinal Tensile Strains* (*Unit Extensions*) as abscissas for the entire course of a tension test.

Figure 1 shows various method of plotting this relationship for the initial portion of a stress-strain curve.

23. *True Tensile Stress-Strain Curve* is the curve obtained by plotting true tensile stresses as ordinates against corresponding true longitudinal tensile strains as abscissas.

24. *Proportional Limit.*—The greatest stress which a material is capable of developing without a deviation from the law of proportionality of stress to strain (Hooke's Law). Since this requires a quantitative definition of "deviation," and various devices possess inherently different capabilities of detecting this deviation, the term is going out of use with the various definitions of yield point and yield strength (25, 26, 27) taking its place.

25. *Yield Point* is the first stress level on the stress-strain curve (whether nominal or true stress should be stated) at which the slope of the curve becomes zero, that is, where the tangent to the curve becomes horizontal, when the test is conducted on a machine having a constant rate of crosshead movement.

It is the stress level at which there occurs a marked increase in strain without an increase in stress (see Fig. 2).

It should be noted that only materials that exhibit this unique phenomenon of yielding have a yield point. The term yield point should not be used in connection with material whose stress-strain diagram does not become horizontal or does not show an actual drop of stress with increase of strain in the region of yield. Two methods of determining yield point are in use:

(*a*) *"Drop of the Beam" Method.* In this method the load is applied to the specimen at any convenient speed of testing up to one half the specified yield point or up to one quarter the specified tensile strength, whichever is smaller, and the operator keeps the beam in balance by running out the poise at approximately a steady rate. When the yield point of the material is reached, the increase of load stops, but the operator runs the poise a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device, there is a sudden halt of the load-indicating pointer corresponding to the drop of the beam. The load at the "halt in the gage" or the "drop of the beam" is recorded, and the corresponding stress is taken as the yield point.

(*b*) *Total Strain Method Using Dividers.* In this method, frequently called the "dividers method," the observer with a pair of dividers or other suitable apparatus watches for visible elongation between two gage marks on the specimen. When visible stretch is observed, the load at that instant is noted, and the stress corresponding to the load is taken as the yield point. For the higher strength steels, a gage length of less than 8 in. is recommended.

26. *Yield Strength.*—The stress above which the material is considered to be damaged, and below which the damaging effects are considered negligible. It is usually impracticable and probably impossible to determine the stress at which inelastic action in a member ***begins***. Plastic yielding in nearly all members (including the specimen in a carefully controlled laboratory test) starts as local actions and becomes measurable only after many local internal adjustments and accommodations have occurred, and after a considerable portion of the member is affected by the yielding.

The limit of usefulness of many materials, especially metals, in members subjected to approximately static loading at ordinary temperatures is therefore determined by a measurable value of plastic yielding of the material above which the material is considered to be damaged and below which the damaging effects are considered to be negligible.

27. *Offset Yield Strength* is the stress at which the stress-strain curve departs from linearity by a specified percentage of deformation (offset). The following methods are recommended for determining the yield strength of a material:

(*a*) *Offset Method.* This method is especially adapted to materials whose stress-strain diagram in the yield range is a smooth curve of gradual curvature.

For nearly all materials, if at any point on the stress-strain diagram such as r in Fig. 3, the load is released, the diagram for decreasing load will follow a line rm approximately parallel to the initial portion OA, of the diagram for increasing load. The offset Om will then give the approximate value of the permanent set after the release of the stress OR. The value of this set is given in percentage of original gage length. Thus to determine the yield strength by the "offset method," it is necessary to secure data (autographic or numerical) from which a stress-strain diagram may be drawn. Then with the stress-strain diagram (Fig. 3) lay off Om equal to the specified value of the set, and draw mn parallel to OA and thus locate r, the intersection of mn with the stress-strain diagram. Draw Rr parallel to the X axis and then OR gives the value of the yield strength.

In reporting values of yield strength obtained by this method, the specified value of "offset" used should be stated in parentheses after the term yield strength. Thus:

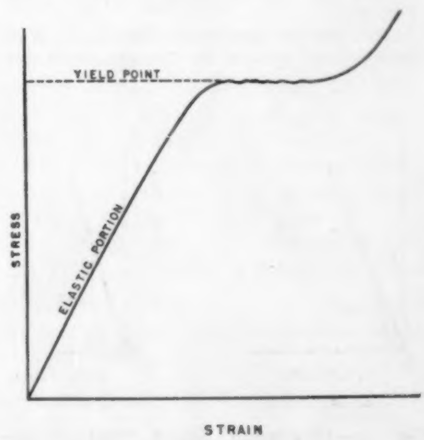


Fig. 2.

Yield strength (offset = 0.1 per cent) = **52,000 psi** indicates that at a stress of **52,000 psi** the approximate permanent set of the material reached the value of 0.1 per cent of the original gage length.

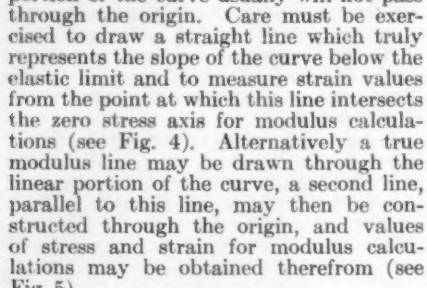
In using this method, an extensometer reading to 0.0001 in. per inch of gage length would be sufficiently sensitive for most materials. The elastic limit and the proportional limit may be regarded as special values of the yield strength. They are the highest stresses for which the "set" and the "offset," respectively, are not measurable with the instruments used.

For any given stress the deviation (offset) from Hooke's law is only approximately equal to the set after the removal of that stress, and the approximation becomes less and less exact as the permissible deviation diminishes. This method is devised for determining a stress corresponding to a well-marked plastic deformation, or set, and it is not feasible to specify a very small value for the permissible "offset" *Om*.

(*b*) *Extension Method Under Load.* For tests to determine the acceptance or rejection of material whose stress-strain characteristics are well known from previous tests of similar material in which stress-strain diagrams were plotted, the total strain corresponding to the stress at which the specified permanent set occurs will be known within satisfactory limits; therefore, in such tests a specified total strain may be used, and the stress on the specimen, when this total strain is reached, is the value of the yield strength. The total strain can be obtained satisfactorily by use of an extensometer reading to 0.0001 in. per inch of gage length. It is recommended that this approximate method be used only after agreement between the manufacturer and the purchaser, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the offset method to settle any misunderstandings.

Since stress-strain data are relatively inaccurate at low values of stress and strain (near the start of the test), the truly linear portion of the curve usually will not pass through the origin. Care must be exercised to draw a straight line which truly represents the slope of the curve below the elastic limit and to measure strain values from the point at which this line intersects the zero stress axis for modulus calculations (see Fig. 4). Alternatively a true modulus line may be drawn through the linear portion of the curve, a second line, parallel to this line, may then be constructed through the origin, and values of stress and strain for modulus calculations may be obtained therefrom (see Fig. 5).

28. *Rate of Loading* is the variation in tensile load carried by the specimen per unit time. It is expressed in pounds per second.



(*a*) Incorrect. (*b*) Correct.

Fig. 4.—Measuring Strain from Stress-Strain Diagram.

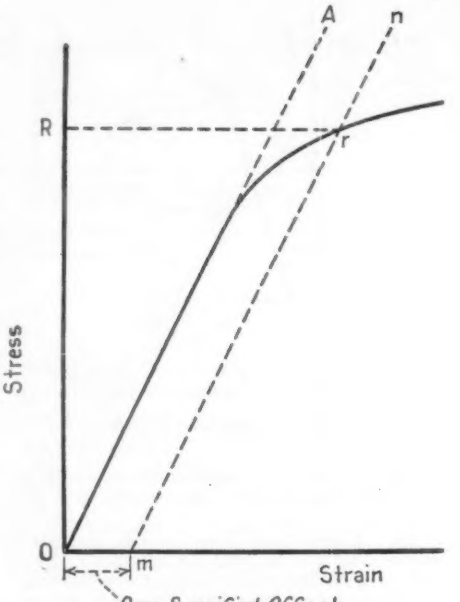


Fig. 3.—Stress-Strain Diagrams.

29. *Rate of Stressing* is the variation in tensile stress per unit time. It is expressed in pounds per square inch per second.

30. *Rate of True Stressing* is the variation in true tensile stress per unit time. It is expressed in pounds per square inch per second.

Note.—At the nominal plastic yield stress, the instantaneous nominal rate of stressing becomes zero, but the instantaneous true rate of stressing may continue to have a positive value if the cross-sectional area is decreasing.

31. *Nominal Rate of Stressing* is the slope of a diagram of stress *versus* time, measured as the slope of a straight line drawn so as to represent the portion of the curve just below the apparent proportional limit of the stress-strain curve. It is expressed in pounds per square inch per second.

32. *Nominal Rate of Straining* is the slope of a diagram of strain *versus* time measured as the slope of a straight line, drawn so as to represent the portion of the curve just below the strain corresponding to the apparent proportional limit of the stress-strain curve. It is expressed as strain per second, or more commonly as strain × 100 per second (per cent per second).

Note.—It is not synonymous with rate of crosshead movement.

33. *Elastic Limit* is the greatest tensile stress which a material is capable of carrying without a permanent deformation remaining upon complete release of the stress.

34. *Elastic Modulus* is the ratio, within the elastic limit of a material, of stress to corresponding strain.

35. *Secant Modulus* of elasticity at a given amount of strain is the corresponding stress divided by the designated strain.

36. *Secant Modulus* of elasticity at a designated stress is the stress divided by the corresponding strain.

Symbols

37. The following symbols may be used for the above terms:

- W = weight load,
- ΔW = increment of weight load,
- L = distance between gage marks at any time,
- L_o = original distance between gage marks,
- L_u = distance between gage marks at moment of rupture,
- ΔL = increment of distance between gage marks = extension,
- A = minimum cross-sectional area at any time,
- A_o = original cross-sectional area,
- ΔA = increment of cross-sectional area,
- A_u = cross-sectional area at point of rupture, measured after breaking specimen,
- A_T = cross-sectional area at point of rupture, measured at the moment of rupture,
- t = time,
- Δt = increment of time,
- σ = tensile stress,
- σ_T = true tensile stress,
- σ_U = ultimate (or tensile) strength,
- σ_{UT} = true ultimate (or tensile) strength,
- ϵ = strain (= unit extension),
- ϵ_U = total strain = total unit extension,
- ϵ_T = true strain,
- $\%El$ = percentage elongation,
- P.Y.S. = yield point, and
- E = elastic modulus.

38. Relations between these various terms may be defined as follows:

$$\sigma = \frac{W}{A_o}$$

$$\sigma_T = \frac{W}{A} = W\,\frac{(1+\epsilon)}{A_o} = \sigma(1+\epsilon)$$

$$\sigma_U = \frac{W}{A_o} \text{ (where } W \text{ is breaking load)}$$

$$\sigma_{UT} = \frac{W}{A} \text{ (where } W \text{ is breaking load)}$$

$$\epsilon = \frac{\Delta L}{L_o} = \frac{L - L_o}{L_o}$$

$$\epsilon_U = \frac{L_u - L_o}{L_o}$$

$$\%\,El = \frac{L_u - L_o}{L_o} \times 100 = \epsilon_u \times 100$$

$$\text{Nominal reduction of area} = A_o - A_u$$

$$\text{Nominal unit reduction of area} = \frac{A_o - A_u}{A_o}$$

$$\text{Nominal percentage reduction of area} = \frac{A_o - A_u}{A_o} \times 100$$

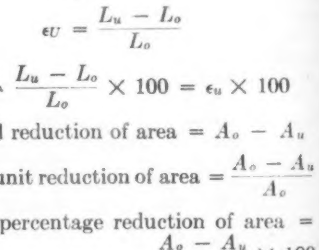


Fig. 5.—Modulus Calculations from Stress-Strain Diagram.

$$\text{True reduction of area} = A_o - A_T$$

$$\text{True unit reduction of area} = \frac{A_o - A_T}{A_o}$$

$$\text{True percentage reduction of area} = \frac{A_o - A_T}{A_o} \times 100$$

$$\text{Rate of loading} = \frac{\Delta W}{\Delta t}$$

$$\text{Rate of stressing} = \frac{\Delta \sigma}{\Delta t} = \frac{\Delta W/A}{\Delta t}$$

$$\text{Rate of true stressing} = \frac{\Delta_{\sigma T}}{\Delta t} = \frac{\Delta W/A}{\Delta t}$$

$$\text{Rate of straining} = \frac{\Delta \epsilon}{\Delta t} = \frac{\Delta L/L_o}{\Delta t}$$

$$\epsilon_T = \int_{Lo}^{L} \frac{dL}{L} = \ln \frac{L}{L_o}$$

For the case where the volume of the test specimen does not change during the test, the following relations hold:

$$\sigma_T = \sigma(1 + \epsilon) = \sigma\left(\frac{L}{L_o}\right)$$

$$\sigma_{UT} = \sigma_U(1 + \epsilon_U) = \sigma_U\left(\frac{L_u}{L_o}\right)$$

$$A = \frac{A_o}{(1 + \epsilon)}$$

DISCUSSION

MR. WALTER RAMBERG.[3]—We are in sympathy with the purpose of the proposed replacement, to make the definitions in E 6 – 36 more generally applicable as a guide in writing ASTM Standards for nonmetals as well as metals. We oppose the replacement only because we believe that it fails in this purpose.

The definitions in E 6 – 36 were arrived at nearly 20 years ago after much discussion and mature consideration. The aim was to confine the definitions to terms of general applicability in standards involving the strength and deformation of materials. The definitions are few in number in accordance with the physical fact that the strength and deformation of most materials can be described in terms of the two concepts of stress and strain. They are stated unambiguously and concisely to appeal to those faced with the problem of drawing up or improving a standard. The reasons for the definitions, their limitations, and their application to specific problems are given in explanatory notes.

The care taken in drawing up definitions E 6 – 36 has paid off in their widespread use in the writing of standards and specifications for structural materials. For example the definitions for "yield strength" and for "tensile strength" have become generally accepted by structural engineers in place of a series of roughly equivalent terms such as yield stress, nominal yield stress, ultimate stress, fracture stress, and unit stress at failure.

Any replacement of E 6 – 36 should live up to the high standards set by these old definitions in respect to general applicability, brevity, and definiteness. The new definitions fail to meet these high standards in several respects. Many terms are included in the proposed revision that are not generally applicable in ASTM Standards. A survey of Part 6 of the Book of ASTM standards (Electrical Insulating Materials, Plastics, Rubber) shows that only 18 of the 37 definitions are mentioned in Part 6. No mention was made of terms such as true ultimate strength, true tensile stress, and total unit extension. The new definitions are less general than the old also in being confined to tension testing, while the old definitions include other types of stress such as compression and shear. The new definitions are repetitious rather than brief and concise. Instead of the one definition for "strain" in the old definitions, we have sixteen definitions relating to strain, including extension, strain, unit extension, total extension, and true percentage reduction in area. We believe that the long list of symbols and formulas comprising definitions 37 and 38 could be omitted, or at least distributed among the preceding definitions, without harm to their usefulness. The new definitions are not as definite as the old. Yield strength formerly defined as "The stress at which a material exhibits a specified limiting permanent set" becomes "The stress above which the material is considered to be damaged and below which the damaging effects are considered negligible." The word "nominal" creeps into the new definitions 31 and 32 to disturb those wondering about the difference between "actual" and "nominal" values. The difference between some of the definitions, such as 35 and 36 for "secant modulus," is so small that it is difficult to decide between them in preparing a given standard.

In view of the above criticism it seems to us that it would be best to reject the proposed replacement and instead to retain the admirable framework provided by definitions E 6 – 36, and to extend this framework to make it applicable to the complete range of materials covered in ASTM product specifications. We believe that such a revision would have the same beneficial effect in "standardizing" ASTM Standards for plastics as it has already had in the case of metals.

MR. H. L. FRY.[4]—These comments are divided into two parts as follows: first, objections to the proposed D 638 definitions as a substitute for E 6 – 36 and second, objections to E 6 – 36 as it stands.

OBJECTIONS TO THE PROPOSED D 638 DEFINITIONS AS A SUBSTITUTE FOR E 6 – 36

Failure to Build from Fundamental Concepts:

In E 6 – 36 all definitions are built from the fundamental concepts of stress and strain. The terms stress and strain are so defined as to be applicable to stresses and strains in tension, compression, or shear or in combinations of these. The definitions cover the use of these terms in any field, physics, mechanics, engineering, or mechanical testing. The other definitions in E 6 – 36 are based on these concepts of stress and strain. Thus, all of our mechanical testing terms are given a firm foundation and an important link with those fields in which the results of mechanical testing are used.

The D 638 definitions fail to follow this in three respects.

(*a*) The definitions to relate only to tension testing. In that case separate definitions of stress and strain in compression and shear, and some secondary concepts, such as yield point and yield strength, modulus, etc., will be required for compression, shear, and tension testing. In E 6 – 36 one simple definition covers all fields.

(*b*) Tensile strength and yield point are not defined in terms of stress and strain in the D 638 definitions.

(*c*) Stress and strain definitions are not given first place in the D 638 definitions.

Failure to Eliminate Objectionable Features of E 6 – 36:

Some of the definitions in the D 638

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definitions are revisions of definitions that are included in E 6 – 36, but the revisions do not eliminate the objectionable features in Definitions E 6 – 36. The definitions referred to here are those for yield strength and yield point. These will be discussed later.

Changes of Nomenclature of Commonly Used Terms:

The terms "elongation" and "reduction of area" are in common use. Anyone unfamiliar with these common terms referring to the D 638 Appendix for enlightenment would find himself faced with a choice of three elongations and six reductions of area. The D 638 Appendix refers to these terms, as they are generally used in testing metals, as "percentage elongation" and "nominal percentage reduction of area." The latter, particularly, does not appear to be a good phrase for common use, and might well lead to confusion.

Multiplicity of Similar Terms:

I cannot judge which of the numerous terms defined in the D 638 definitions are important in the field of testing nonmetallic materials, but I should certainly favor some arrangement of the definitions which would separate the important ones from those less commonly used.

Miscellaneous Minor Objections:

I do not think that definition 5 should apply to the definition of strain.

The last sentence in definition 14 is unnecessary as it repeats 5.

The meaning of the note in definition 30 is very far from being clear to me. The term "nominal plastic yield stress" has not been defined. The "nominal rate of stressing" is said in definition 31 to be "below the apparent proportional limit." It is difficult to see how any phenomenon called "nominal plastic yield stress" could be below the apparent proportional limit.

In regard to definition 33 I should like to see some note added to the effect that elastic limit is not a property that can be determined practically in conventional testing procedures for general acceptance purposes.

OBJECTIONS TO E 6 – 36

All actual definitions in E 6 – 36 except that for yield strength, and possibly also the one for yield point, are quite satisfactory as they stand. The objectionable features of E 6 – 36 lie in the methods of determining yield strength and yield point that are included. I am inclined also to criticize the paragraphs on the methods of making a stress-strain diagram.

I feel that these methods of testing do not properly belong in E 6 – 36 and should be eliminated entirely. If they can be eliminated, then only the following revisions seem desirable.

Definition of Yield Strength:

The definition of yield strength given in E 6 – 36 is objectionable to my mind in that it implies a method of testing that is rarely if ever used. I am not here advocating a definition in terms of test method, but I should like to have a definition such that the usual test method results in a direct rather than an indirect measure of the property defined. At present we say that the yield strength is the stress at which a material exhibits a specified permanent set. But then in making the test we measure not a permanent set, but a certain degree of plastic strain, and say that this is approximately the same thing. I would therefore revise the definition to say that "yield strength is the stress which produces in the material, under the specified conditions of the test, a specified limiting plastic strain." The offset provides this in the case of metals at least.

I have inserted that phrase "under the specified conditions of the test" because I believe this might make this definition applicable to the testing of plastics. A note might be added here that the specified conditions of the test referred to may include speed of testing, method of measuring plastic strain, or any other conditions necessary for testing a particular material.

This definition might meet the objections that were raised to the one proposed in the D 638 Appendix on the ground that "damage" was an ill-defined word.

Definition of Yield Point:

I feel that the present definition of yield point in E 6 – 36 is satisfactory but that the note which follows the definition should be changed to read somewhat as follows:

"It should be noted that not all materials exhibit this phenonenon defined as yield point. In some cases it is not possible to know in advance of making a test whether the particular specimen will exhibit a yield point by drop of beam or halt of gage. Therefore, when the yield point is specified in a product specification, the method of testing prescribed should provide for an alternative value that may be reported as the equivalent of yield point in case a yield point (as presently defined) is not found."

In comparing the definitions of yield point in E 6 – 36 and the D 638 Appendix, I feel that they both say the same thing, but the E 6 – 36 definition says it in more fundamental terms and is therefore preferable. I have the impression that in dealing with plastics it is necessary to distinguish between the first and possible subsequent points of zero slope on the curve, but I believe that this could still be done in the fundamental terms of stress and strain rather than in terms of the stress-strain curve, which is not a necessary part of every test for yield point.

If the test methods must be left in E 6 – 36, then I should favor revisions similar to those that have been written by some of the product subcommittees of Committee A-1 on Steel. These revisions specifically would be as follows:

1. Yield Strength.

(*a*) Revision so that on a material with a sharp kneed stress-strain diagram the same result is obtained whether the diagram is produced autographically or by plotting from strainometer readings.

(*b*) Elimination of the last paragraph of method (*a*).

2. Yield Point.

(*a*) Addition of a method consistent with the revised note that I suggested above. A method that could be added here, which would be consistent with what has been agreed upon in Committee A-1, would be the method in which yield point is considered as the stress required to produce a certain specified total of elastic and inelastic strain (that is, total extension under load). The amount of this total strain should be specified in the product specifications.

(*b*) Revision of section (*a*) in which there is a gap in the outlined procedure between one half the yield point and the yield point.

With these suggested revisions of E 6 – 36 I feel that we would be in a position to add definitions of those terms that are needed in the testing of nonmetallic materials, thereby accomplishing the original purpose of the Task Group.

Oxidation of Alloys by the Wire Life Test Method

By Anton deS. Brasunas[1] and Herbert H. Uhlig[2]

The ASTM wire life test for evaluating electric heating wire (B 76–39)[3] makes use of an 0.025-in. diameter wire, heated electrically for cycles of 2 min on and 2 min off. The test is continued until either the wire fails or the electric resistance increases by 10 per cent. A disappearing filament pyrometer is used for measuring temperature. The test evaluates the combined resistance of the alloy wire to high-temperature oxidation and to spalling of protective oxides (spalling produced by alternate heating and cooling). The latter property is often by far the more important in determining the practical value of an alloy for high-temperature service.

The authors previously suggested several improvements in this test setup **(1)**,[4] which were used in obtaining the data reported herewith. A bank of modified test units is shown in Fig. 1.

Our use of the life test method was for rapid evaluation of alloys and various metal surface treatments for high-temperature oxidation. The advantages of the life test for this purpose are as follows:

1. Any temperature up to the melting point of the alloy can be obtained rapidly and conveniently.
2. The alloy can be subjected conveniently to cyclic heating and cooling as a means for evaluating spalling characteristics (for example, automatically switching current on and off).
3. Only a small amount of alloy is needed for a single test.
4. The surrounding atmosphere can be easily controlled.

There are also some disadvantages of the test from the standpoint of evaluating general oxidation resistance of alloys. Although these were not important to our immediate objectives, they might nevertheless be listed:

1. The test is applicable only to compositions of alloys that can be made into wires.
2. The electric resistance varies during the test; therefore the voltage must be adjusted frequently if a constant temperature is to be maintained (the use of a photoelectric controller would help).
3. Wire specimens must contain a minimum of metallurgical flaws such as inclusions; otherwise failure occurs prematurely.
4. Wires subject to high creep at elevated temperatures fail prematurely because the wire cross-section diminishes, followed by higher electrical resistance and higher temperature.

Experimental Procedure

Control of Atmosphere:

Because humidity was found to be a sensitive factor in the life of alloy wires in this test, all our experiments were conducted in air of controlled humidity. Air was humidified by passing through fritted glass tubes submerged in distilled water, which was maintained at 25 C ± 0.01 C. Less than 100 per cent relative humidity was obtained by passing humidified air through fritted glass tubes submerged in suitably saturated salt solutions containing excess salt which was similarly maintained at 25 C. Air was dried by passing it through a trap cooled by dry ice - acetone mixture (− 79 C), thereby reducing water content to 0.00006 per cent by volume. Calibrated hair hygrometers placed in the air line on either side of the test chamber were used to check the humidity during a test run.

The rate of air flow through the test chambers was maintained at 600 ml per min, which is equivalent to an average linear gas flow of 2 in. per min in the test chambers (neglecting convection currents), or a theoretical replacement of atmosphere every 10 min. Chemical analysis of the exit air atmosphere

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[2] Corrosion Laboratory, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

[3] Method of Accelerated Life Test for Metallic Materials for Electrical Heating (B 76–39), 1949 Book of ASTM Standards, Part 2, p. 623.

[4] The boldface numbers in parentheses refer to the list of references appended to this paper.

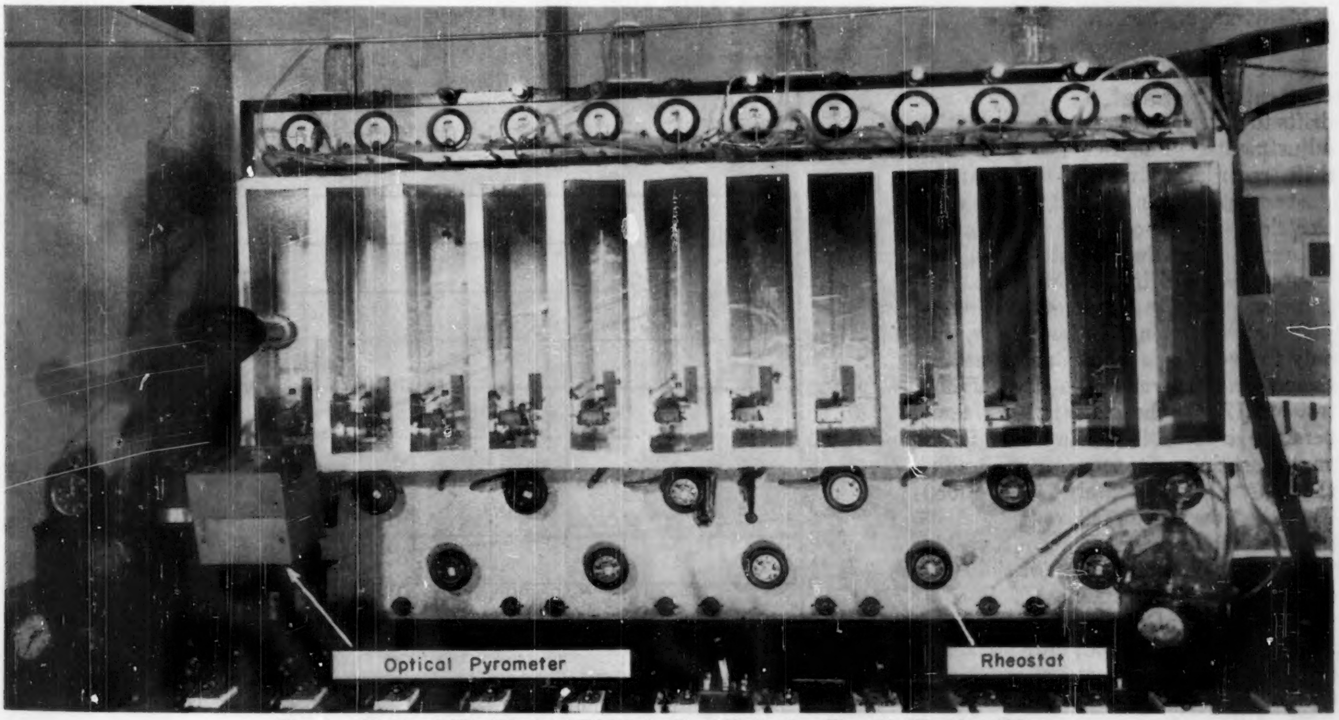


Fig. 1.—Bank of Modified ASTM Life Test Units for Electric Heating Wires.

showed a negligible change of oxygen content at this rate of flow.

It was found that the asbestos board from which the ASTM-specified test chamber is constructed emits and absorbs moisture during the test, making humidity control difficult. To avoid this source of variable humidity, the inside surface of the chamber was impregnated with bakelite lacquer (BL 3128) and lined with aluminum foil 0.001 in. thick.

Another source of variable humidity was the entrance of air from the outlet of the chamber each time the wire specimen was cooled. This was overcome by connecting the outlet to a 500 ml air reservoir. The air, therefore, entering the chamber during the cooling part of the cycle was of approximately the same humidity as that maintained during the heating cycle.

Use of ordinary rubber tubing for air lines causes contamination by undesirable sulfur or sulfur-bearing compounds. We found it advisable to use pure (sulfur-free) gum rubber or Tygon plastic tubing to reduce contamination from this source.

Temperature Control:

Temperature measurements were corrected for oxide emmissivity and transmission through the glass window. Fifteen degrees Centigrade (27 F) were added to the optical readings in the vicinity of 1175 C (2150 F). A temperature gradient along the wire, as described previously (1), made it advisable to record temperature measurements slightly below the center of the specimens, averaging 7 in. from the top of the wire.

Since the ASTM test is essentially a constant-voltage test, the temperature drifts to lower values after certain initial adjustments. The magnitude of this drift, recorded at various times during the test, is shown in Fig. 2, together with electrical resistance and temperature changes both with and without adjustments prescribed by ASTM test conditions, wherein the temperature is readjusted after 15 min, 5 hr, and 24 hr, but only the voltage is maintained constant thereafter. Therefore, in the ASTM test at 1175 C, the indicated test temperature is actually maintained for a very short time; the temperature gradually falls to approximately 1120 C (2050 F) at the time of wire failure.

Several hours prior to failure, a visible "hot spot" develops which rapidly increases in temperature until it reaches the melting point of the wire. Note in Fig. 2 that the "hot spot" has no measurable effect on the electrical resistance of the hot wire under test.

The failure of one or more wires of a group frequently causes fluctuation in the line voltage, thereby altering the temperature of the remaining wires. This was overcome in our setup by the use of dummy wires, switched automatically into the circuit by means of relays, to replace individual wires burned out.

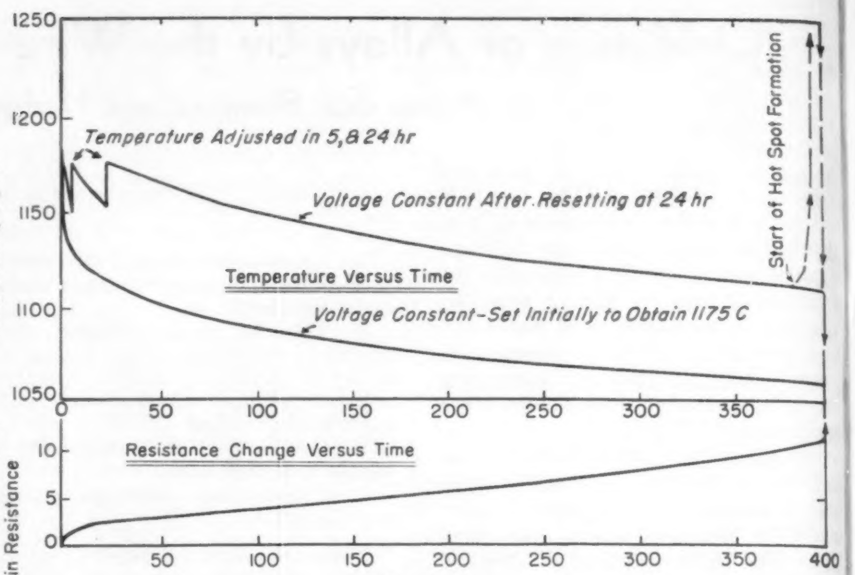


Fig. 2.—Typical Behavior of 80 Ni, 20 Cr Wire Tested at 1175 C (2150 F) in Air of Approximately 60 per cent Relative Humidity.

Effect of Stress:

The 10-g load acting as the lower electrical terminal of the wire specimen exerts a stress of 45 psi on a wire of 0.025-in. diameter. Furthermore, the weight of the wire specimen itself increases this to 48 psi at the upper end of the wire. Hence, other things being equal, the failure tends to occur at the upper end of the wire where the stress is greatest. This has actually been observed in more than 90 per cent of wires tested.

The operating stress on the wire is increased during the test as the cross-sectional area is reduced by oxidation and, in certain cases, also by creep. It was found, in general, that at the time of failure of the 80 Ni, 20 Cr type alloy, the wire had a residual diameter of only 0.015 in. which corresponds to a stress of approximately 125 psi under the same 10-g load (assuming that the oxide does not support any load nor add to it).

Very little creep was noticed for the 80 Ni, 20 Cr alloy even at 1225 C. The rate of extension at 1225 C was 0.03 in. per ft in 100 hr. However, appreciable creep occurred when certain other alloys were tested, the rate being as much as 1.5 in. per ft in 24 hr for the 26 Cr, Fe alloy. Creep rates of this magnitude constitute a drawback of the wire test method for measuring oxidation rates, but fortunately most wires tested at temperatures corresponding to service conditions have low creep rates.

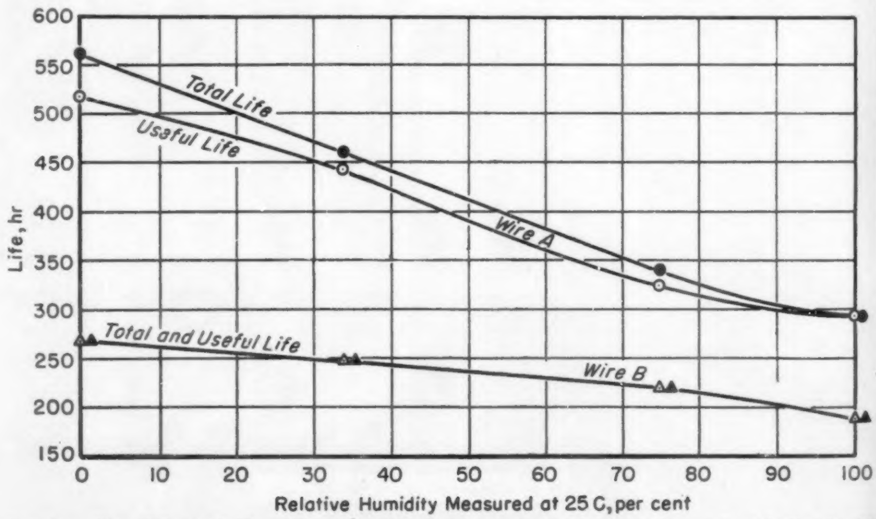


Fig. 3.—The Effect of Humidity on Life of 22 gage (0.025 in.) Commercial Grade 80 Ni, 20 Cr Wire at 1175 C (2150 F) as Determined by ASTM Life Test B 76 – 39.

Results

Effect of Humidity:

The life of wires from two separate commercial heats of 80 Ni, 20 Cr alloy (referred to as A and B) tested by the standard procedure was found to vary approximately inversely with the humidity of the ambient air. The average test data are plotted in Fig. 3. Useful life, as defined by the ASTM life test, is the total time during which electrical resistance of the wire changes by 10 per cent, whereas total life is the time to failure.

The need for humidity control in tests of this kind is made clear by these data, especially for the wire having longer life. The wire which fails in shorter time appears less sensitive to moisture.

Effect of Temperature:

Because of the sensitive effect of humidity, all tests reported hereafter were obtained in air of 100 per cent humidity. The decrease in total and useful life of 80 Ni, 20 Cr alloy wires, as the test temperatures increase, is given in Table I and plotted in Fig. 4, together with similar data for wire specimens of other compositions. The short life of low-alloy wires made it difficult to obtain adequate electrical resistance data for determining useful life, and for this reason the data are omitted for the 5 Cr, Fe and 12 Cr, Fe alloys.

Abnormally high temperatures during the test were obtained in a few cases where the wire life was extremely short. This was caused by heat liberated by rapid oxidation of the wire.

As is evident from Fig. 4, a plot of the logarithm of total life with reciprocal of the absolute temperature results in a straight line, indicating that an equation similar to the Arrhenius reaction rate equation applies:

$$L = Ae^{E/RT}$$

where:

L = life in hours,
A and E = constants,
R = the gas constant equal to 1.99 calories per mole, and
T = the absolute temperature.

The alloys most resistant to oxidation are also more sensitive to changes in temperature insofar as life is concerned.

Effect of Surface Contamination:

According to modern theory, oxidation rate depends on both the ease with which metal ions can diffuse through the oxide and the ease with which electrons can move from the metal-oxide interface to the oxide-gas interface (good conductivity). These factors can be altered by surface contamination, in particular by salts that may either affect lattice vacancies of the oxide (affecting diffusion of ions) or increase electrical conductivity. It was of interest, therefore, to determine how sensitive wire life is to various salts on the wire surface. The technique used was to abrade the wire specimens under water with very fine water-resistant, abrasive paper (No. 500A), then dip the wires into one-molar solutions of various salts. The wires were dried and tested in the usual manner. Results using type 502 (5 per cent Cr) steel and 80

TABLE I.—VARIATIONS IN WIRE LIFE WITH TEMPERATURE, FOR SEVERAL COMPOSITIONS, IN AIR OF 100 PER CENT RELATIVE HUMIDITY (25 C) USING THE ASTM TEST B 76–39.

Composition	Temperature deg Cent	Useful Life, hr	Total Life, hr
80 Ni, 20 Cr.....	1175	294.0	295.0
	1200	145.0	149.0
	1225	117.2	122.8
	1250	80.0	108.3
	1300	26.0	31.2
26 Cr........	900	175.0	>650
	1000	35.7	148.0
	1050	17.4	68.3
	1100	9.2	30.5
	1150	6.3	26.1
16 Cr........	850	295.0	>500
	900	77.0	141.0
	950	23.1	91.5
	1000	11.7	52.4
	1050	5.2	22.6
	1100	3.3	17.1
12 Cr........	850	...	120.0
	900	...	31.0
	950	...	25.2
	1000	...	14.2
	1050	...	5.4
	1100	...	2.9
5 Cr........	825	...	9.2
	850	...	6.5
	900	...	5.2
	1025	...	1.3

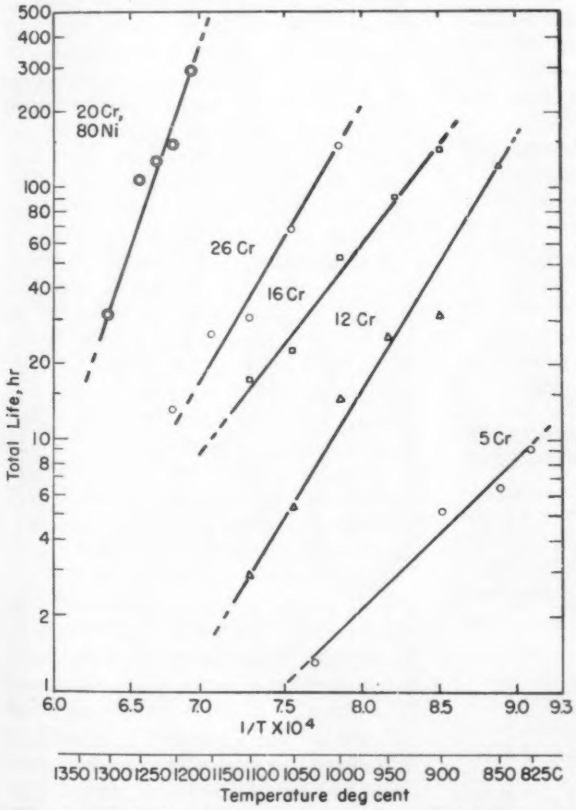
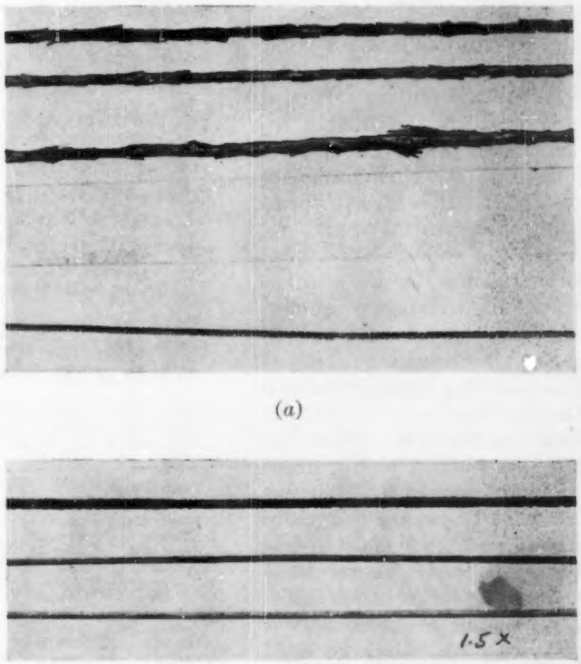


Fig. 4.—Variation with Temperature of Total Life of Wires in Air of 100 per cent Relative Humidity at 25 C.



(a)

(b)

Fig. 5.—Appearance of Type 502 Wires (5 Cr) After Testing at 900 C in Moist Air Using (a) the Cyclic ASTM Test Cycle and (b) Continuous Heating.

TABLE II.—EFFECT ON WIRE LIFE BY SALT SOLUTIONS APPLIED TO THE SURFACE. TEST ATMOSPHERE: AIR OF 100 PER CENT RELATIVE HUMIDITY.

Average of Three Tests.

Salt Solution[a]	20 Cr, 80 Ni Tested at 1250 C		5 Cr, 95 Fe Tested at 900 C	
	Total Life, hr	Ratio Life-treated / Life-untreated	Total Life, hr	Ratio Life-treated / Life-untreated
Untreated	108	(1.0)	5.2	(1.0)
$NaCl$	48	0.44	13.1	2.5
Na_2SO_4	56	0.52	2.2	0.42
$NaOH$	68	0.63	4.2	0.81
$NaNO_3$	69	0.64	3.9	0.75
$Na_4P_2O_7$	69	0.64	9.0	1.7
Na_2S	74	0.68	2.5	0.48
$Na_2B_4O_7$	83	0.77	3.4	0.65
$Na_2Cr_2O_7$	84	0.78	4.5	0.87
Na_2SiO_3	88	0.81	4.0	0.77
Na_2CO_3	90	0.83	4.8	0.92
$CaCl_2$	85	0.78	11.1	2.1
KCl	68	0.63	10.0	1.9
$K_2Cr_2O_7$	80	0.74	4.1	0.79
KNO_3	94	0.87	3.5	0.67
K_2CO_3	82	0.76	4.5	0.87
$Ce(HSO_4)_3$	70	0.65	7.2	1.4
$Ce(CO_3)_3$	91	0.84	4.7	0.90
$Th(NO_3)_4$	92	0.85	4.3	0.83

[a] 1-Molar solutions wherever solubility permitted; otherwise saturated solutions.

Ni, 20 Cr alloy wires in triplicate are summarized in Table II.

The action of these surface salts appears to alter the life of the wires by either (1) affecting the oxidation rate, or (2) by affecting adherence of the oxide to the parent metal during the heating cycles. The latter effect was especially apparent in the case of the 5 per cent Cr steel wire shown in Fig. 5. This subject deserves further study, because of its practical importance.

Effect of Wire Pretreatment:

Because the oxide which forms naturally on a metal specimen at high temperatures serves as a diffusion barrier, the resistance of an alloy to elevated temperatures is determined by the composition and structure of such an oxide. Both chromium and aluminum are metals especially resistant to attack at elevated temperatures presumably because of favorable properties of their oxides in resisting the combination of metal and oxygen. It is logical, therefore, that any pretreatment of an alloy that increases the concentration of a metal like chromium at the surface should improve its oxidation resistance. One way in which this can be done is to heat a chromium-containing alloy at high temperatures in a hydrogen atmosphere containing water vapor. Chemical equilibria in this atmosphere are such that it is possible to oxidize chromium, aluminum, and silicon, but not iron and nickel. Therefore, if a chromium-iron alloy is heated in moist hydrogen, the oxide film should be either entirely Cr_2O_3, or at least rich in this oxide, and the corresponding oxidation rates of alloys so pretreated should be lower than the rates normally observed.

The tendency of chromium, aluminum, and silicon to oxidize in moist hydrogen, but not iron or nickel, can be determined from the free-energy changes accompanying the oxidation of these metals. Values of free-energy, as listed by Richardson and Jeffes (**2**) at 1175 C (2150 F), are as follows:

Reaction	$\Delta F°$ per mole O_2, calories
$2Fe + O_2 \rightarrow 2FeO$	−81 000
$2Ni + O_2 \rightarrow 2NiO$	−49 000
$^4/_3Cr + O_2 \rightarrow {}^2/_3Cr_2O_3$	−118 600
$Si + O_2 \rightarrow SiO_2$	−146 000
$^4/_3Al + O_2 \rightarrow {}^2/_3Al_2O_3$	−193 500
$2H_2 + O_2 \rightarrow 2H_2O$	−79 000

Hence, in hydrogen saturated with moisture, at 25 C, the partial pressures of H_2 and H_2O being 0.969 atmosphere and 0.031 atmosphere respectively, the free-energy change under actual test conditions can be computed from the equation:

$$\Delta F = \Delta F° + RT \ln \frac{\text{products}}{\text{reactants}}$$

For the reaction

$$Fe + H_2O \rightarrow FeO + H_2$$

it follows that

$$\Delta F° = -1000 \text{ cal per mole Fe}$$

and

$$\Delta F = -1000 + RT \ln \frac{p_{H_2}(FeO)}{p_{H_2O}(Fe)}$$

where (FeO) and (Fe) represent activities of these substances, values of which are unity for FeO and nearly unity for Fe. Hence

$$\Delta F = -1000 + 1.99 \times 1448 \times 2.303 \log \frac{0.969}{0.031}$$

$$= +8900 \text{ cal}$$

Therefore, the oxidation of iron under these conditions is not thermodynamically possible. Nickel, similarly, is not oxidized.

For chromium, however,

$$^4/_3Cr + 2H_2O \rightarrow {}^2/_3Cr_2O_3 + 2H_2 \quad \Delta F° = -39{,}600 \text{ cal}$$

and

$$\Delta F = -39{,}600 + 1.99 \times 1448 \times 2.303 \log \frac{p^2_{H_2}(Cr_2O_3)^{2/3}}{p^2_{H_2O}(Cr)^{4/3}}$$

(Cr_2O_3) is again unity, but (Cr) is approximately (0.2) in a 20 per cent Cr, Ni alloy. Accordingly,

$$\Delta F = -39{,}600 + 1.99 \times 1448 \times 2.303 \log \frac{0.969^2}{0.031} - {}^4/_3(1.99 \times 1448 \times 2.303) \log (0.2) = -13{,}500 \text{ cal}$$

This reaction, therefore, is possible and actually occurs. Silicon and aluminum, whose free-energy changes are even more negative, can also be shown to oxidize under these conditions.

Accordingly, wires of chromium-iron and nickel-chromium alloys were exposed to moist hydrogen at 1175 C (2150 F) for various lengths of time and then tested as usual. The pretreatment in hydrogen saturated at room temperature with water vapor took place in Pyrex-glass tubes, through which the gas passed at a rate of 200 ml per min. The wires were heated to temperature electrically and after the pretreatment were removed to the ASTM test chamber.

As predicted, appreciable improvement in corrosion resistance was observed. For example, an alloy of 80 Ni, 20 Cr untreated had a total life of 295 hr at 1175 C in air of 100 per cent relative humidity, whereas, a wire pretreated for 2 hr at 1100 C in moist hydrogen had a resultant life of 539 hr or approximately 80 per cent longer life. With 5 per cent Cr, Fe wires, pretreatment resulted in relative improvement up to eightfold (Table III).

TABLE III.—THE EFFECT OF PRETREATMENT IN MOIST HYDROGEN ON THE LIFE OF 5 Cr WIRE AT 900 C (1650 F).

Temperature of Pretreatment, deg Cent	Time of Pretreatment, hr	Total Life, hr	Relative Improvement
None	None	2	(1.0)
900	2	3.4	1.7
900	9	3.6	1.8
900	21½	6.9	3.5
1000	2	8.4	4.2
1000	10	13.3	6.7
1000	20	17.5	8.8
1100	2	14.0	7.0
1100	8½	13.2	6.6
1100	19	16.7	8.4

Not all alloys containing chromium, silicon, and aluminum were found to be improved by the moist hydrogen pretreatment. Presumably, in some cases the oxide formed is not Cr_2O_3, but may be a chromite or some other compound for which the free-energy conditions differ from those calculated above. Chen and Chipman, for example, found that in the melt at 1595 C, chromite is the stable solid phase in equilibrium with

the metal for alloys containing 5.5 per cent chromium, while at higher percentages of chromium, the stable phase is Cr_2O_3 (3). A similar situation probably applies for lower temperatures but with the critical chromium concentration occurring at some other value. Another factor is that the oxide-to-metal adherence must be good if the pretreated oxide is to be effective. This is not always the case for alloys containing various constituents in addition to chromium or aluminum.

Acknowledgment:

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A Wide-Range A-C Bridge Test for Magnetic Materials

By D. C. Dieterly[1] and C. E. Ward[1]

In a-c testing of magnetic materials the principal objective is to determine the magnetic properties in such a manner that designers of electrical equipment may use the data to evaluate properly the performance of existing and proposed designs. Fifteen years or so ago, it was usually sufficient to know the core loss and perhaps the excitation loss (apparent core loss), of a magnetic material at 60 cycles for some induction in the range of 10 to 14 kilogausses, (64.5 to 90.3 kilolines per sq in.). Often the excitation loss was estimated from permeability tests made by d-c methods because the a-c test method for core loss normally utilized a magnetic circuit having butt joints, and this made accurate data on excitation requirements impossible due to the preponderant effect of the excitation requirements for the joints. For some few types of electrical equipment, the core loss and excitation properties (and sometimes the permeability) at low inductions in the range of 10 to 1000 gausses (64.5 to 6450 lines per sq in.) were of primary interest.

Until recent years the a-c test methods recommended in ASTM Method A 34 – 49[2] have given sufficient data for the solution of most design problems. However, in the past decade the scope of application of magnetic materials has broadened tremendously. With the advent of new and especially of thinner magnetic materials, it became desirable to determine their magnetic characteristics over a wider range of test conditions than was commonly needed before. Frequently, applications began to require design information at field strengths ranging from extremely small values up to magnetizing forces of about 50 oersteds, and at frequencies ranging from the commercial power frequencies up to the highest frequencies that could be used for a given thickness of material without excessive loss of quality due to skin effect.

The chief difficulty in developing test data for some of the more recent applications of magnetic materials has been the frequency limitations imposed by the present methods described in ASTM Method A 343 – 49.[3] The frequency range for reliable core loss testing by the Epstein method was increased to 15,000 cycles by the use of a special reflecting dynamometer wattmeter constructed in the Armco Research Laboratories ten years ago. This enabled tests to be made at loss levels greater than 0.1 watt at frequencies up to the point where wattmeter errors began to become appreciable. For tests at still higher frequencies, special equipment was needed to overcome the obvious difficulties, since neither the Owen bridge nor a-c potentiometer methods give reliable results at much above 1000 cycles as currently used and instrumented.

Because of this situation an experimental program was begun at Armco Research Laboratories several years ago to investigate various test methods to determine what equipment would give the higher-frequency test data with the greatest accuracy, speed, and versatility. Bridge circuits, of course, offered the most promise for working with very small energy losses. Maxwell, Hay, and resonance bridges were tried, and compared with the present standard method, the Owen bridge, over a wide range of conditions. Most of these circuits gave reliable results up to 10 kc when used with a specially constructed test frame. The special frame had negligibly small distributed capacitance and leakage reactance, even at quite high frequencies where most of these methods would not give reliable data because of errors due to other factors. However, the Hay bridge circuit enables the values of the circuit parameters to be such that undesirable quadrature effects in the resistances and reactances can be made small enough to permit accurate testing up to 200 kc with regular commercial components of high quality. When the basic Hay bridge circuit is modified to provide compensation for winding resistance losses, the balance equations become independent of frequency and so simple in nature that test data can be obtained with remarkable speed and convenience.

The conventional Hay bridge circuit has long been used to determine normal and incremental inductance of iron-core reactances, but not in a manner that would facilitate obtaining accurate data in terms of magnetic properties of the core material under the same general conditions of wave form as in the Epstein method. The authors will attempt to supply in this article pertinent information on the application of the modified Hay bridge circuit to this objective.

General Features of the Hay Bridge Test

The basic Hay bridge circuit employs adjustable resistance and capacitance components to balance against the effective resistance and inductive reactance of the unknown. However, in testing magnetic materials we are interested in determining the extent of the contribution the magnetic material makes to the effective resistance and inductance of the unknown, independently of effects associated with the particular test windings used. To accomplish this, the resistance of the test winding and any

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[2] Standard Methods of Testing Magnetic Materials, (A 34 – 49) 1949 Book of ASTM Standards, Part 1, p. 1145. Tentative revision, 1950 Supplement to 1949 Book of ASTM Standards, Part 1, p. 314.

[3] Standard Methods of Test for Alternating Current Core Loss and Permeability of Magnetic Materials, (A 343 – 49) 1949 Book of ASTM Standards, Part 1, p. 1168.

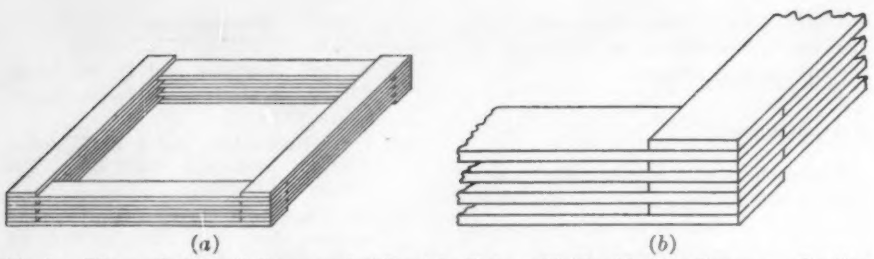


Fig. 1.—Magnetic Circuit Composed of Epstein Strips with Double-Lap Corners. Section (b) shows details of overlapping arrangement of sample strips.

unwanted reactances need to be eliminated from the measurements. Leakage reactance may be reduced to a minimum by providing a test coil uniformly wound over the whole length of the magnetic circuit. If the specimen is composed of Epstein strips, the joints in the magnetic circuit should be double-lapped (Fig. 1) to assure minimum joint reluctance. Distributed capacitance may be minimized by making the winding a single layer, and spacing the turns from each other and from the core when working at high frequencies. The resistance of the test winding is then taken care of by inserting a proper value of resistance across the bridge arm opposite that containing the unknown, in this way also making the balance parameters independent of frequency. Since the current in the test winding (and consequently the test induction) is not affected by balancing, balance may be achieved quite rapidly.

Balance Equations:

A circuit diagram of the Hay bridge, modified to provide compensation for winding losses, is shown in Fig. 2. The test winding and its magnetic circuit is assumed to consist of an inductive component, L_1, paralleled by a resistance or core loss component, R_d. For normal testing, the circuit connected to N_2 is open. When incremental tests are being made, S_3 is closed and the impedance Z is made large enough that the reflected impedance is sufficiently high to avoid any appreciable shunting effect of the d-c circuit.

If R'_w is made to be of such value that

$$R'_w = \frac{R_a R_c}{R_w} \quad \text{.........} (1)$$

where R_w is the d-c resistance of the test winding and leads, then, for any frequency,

$$R_d = \frac{R_a R_c}{R_b} \quad \text{..........} (2)$$

and

$$L_1 = R_a R_c C_b \text{.........} (3)$$

Magnetic Properties from Bridge Parameters:

We may then calculate the a-c permeability from the inductance L_1 using the well-known relationship for the inductance of a uniformly wound toroid

where

$$L_1 = \frac{0.4\pi N^2 \mu_{ac} A}{10^8 l_1} \text{ henrys} \text{.....} (4)$$

then

$$\mu_{ac} = \frac{10^8 l_1 L_1}{0.4\pi N_1{}^2 A} = \frac{10^8 l_1 R_a R_c C_b}{0.4\pi N_1{}^2 A} = K_1 C_b \text{ ....} (5)$$

where:

μ_{ac} = effective a-c permeability of magnetic material,
l_1 = active length of magnetic path in cm,
A = cross-sectional area of magnetic material in sq cm,
N_1 = number of turns in the test winding, and
K_1 = constant which may be evaluated for a given set of test conditions.

The derivation of the bridge equations assumes that both the induction and exciting current wave forms are sinusoidal, a condition which cannot exist due to the nonlinear nature of the magnetization curve. However, at moderate and low inductions the wave forms are nearly sinusoidal, and so the values of a-c permeability so obtained are not too far from d-c values. At inductions substantially above the maximum permeability point, an effort is usually made to maintain sinusoidal wave form of flux by keeping R_c small compared to the reactance of the unknown, L_1. If permeability data are desired to approximate d-c values at these high inductions it is better to measure $E_{(3-6)}$ with a peak voltmeter so as to obtain peak values of the exciting current. Values of H_{max} may then be calculated from peak values of exciting current. These closely approach d-c values of H for inductions well above the maximum permeability point at low frequencies. For all practical purposes, we can determine the total core loss from R_b as follows:

$$P_c = \frac{E^2_{(5-6)}}{R_d} = \frac{E^2_{(5-6)} R_b}{R_a R_c} \text{ ...} (6)$$

Normally, the voltage used in determining the core loss is taken across terminals 5 and 6, although this is slightly in error due to the voltage drop in the winding resistance. This error is usually negligible except perhaps at very low inductions near initial permeability where the IR drop in the windings may be appreciable. In this case the induction may be determined more accurately by means of voltage measurements on an unloaded secondary winding.

The exciting current is determined by measuring the voltage across the resistance R_c: so that,

$$I_{exc} = \frac{E_{(3-6)}}{R_c} \text{..........} (7)$$

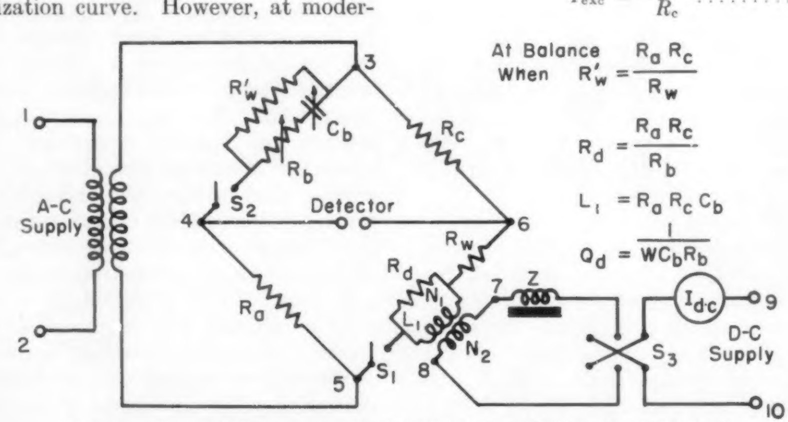


Fig. 2.—Circuit Diagram for the Modified Hay Bridge Test Method.

GENERAL EQUATIONS FOR DETERMINING MAGNETIC PROPERTIES UNDER ANY TEST CONDITIONS:

$$L_1 = \frac{0.4\pi N_1{}^2 u_{a\text{-}c} A}{10^8 l_1} \qquad P_c = \frac{E^2_{5-6}}{R_d} = \frac{E^2_{5-6} R_b}{R_a R_c} \text{ Watts}$$

$$\mu_{a\text{-}c} = \frac{l_1 R_a R_c C_b 10^8}{0.14\pi N_1{}^2 A} K_1 C_b \qquad P_a = E_{5-6} I_{exc} \text{ Apparent Watts}$$

$$I_{exc} = \frac{E_{3-6}}{R_c} \qquad P_q = \frac{E^2_{5-6}}{\omega L_1} = \frac{E^2_{5-6}}{\omega C_b R_a R_c} \text{ Vars}$$

FOR TESTS AT A FIXED FREQUENCY, THE USUAL MAGNETIC PROPERTIES ARE:

$$\mu_{a\text{-}c} = K_1 C_b \qquad \frac{P_a}{m_1} = \frac{E_{5-6} I_{exc}}{m_1} = K_3 B I_{exc}$$

$$\frac{P_c}{m_1} = \frac{E^2_{5-6} R_b}{R_a R_c m_1} = K_2 B^2 R_b \qquad \frac{P_q}{m_1} = \frac{E^2_{5-6}}{\omega C^b R_a R^c m_1} = \frac{K_4 B^2}{C_b}$$

m_1 = Active sample weight

The apparent core loss will then be

$$P_a = E_{(5-6)}\, I_{exc} \quad \ldots\ldots\ldots(8)$$

By the same reasoning, the reactive or wattless power, commonly called vars, will be:

$$P_q = \frac{E^2_{(5-6)}}{\omega L_1} = \frac{E^2_{(5-6)}}{\omega C_b R_a R_c} \quad \ldots\ldots(9)$$

It can be shown by calculating the series equivalent of the parallel combination of L_1 and R_d that the ratio of the equivalent series reactance to the equivalent series resistance, the figure of merit commonly called Q, will be equal to the ratio of the vars to the watts, or,

$$Q_d = \frac{E^2_{(5-6)}\omega L_1}{E^2_{(5-6)} R_d} = \frac{1}{\omega C_b R_a R_c}\cdot\frac{R_a R_c}{R_b} = \frac{1}{\omega C_b R_b} \quad \ldots\ldots\ldots(10)$$

For most practical work, the specific losses (core loss and excitation loss per unit of weight) are of greatest usefulness. For any particular specimen, the specific core loss will be as follows:

$$\frac{P_c}{m_1} = \frac{E^2_{(5-6)} R_b}{R_a R_c m_1} = K_2 B^2 R_b \quad \ldots(11)$$

where m_1 is the active weight of the test specimen, and K_2 is a constant which may be evaluated for tests at a fixed frequency on the test specimen. Then the specific apparent core loss is

$$\frac{P_a}{m_1} = \frac{E_{(3-6)} I_{exc}}{m_1} = K_3 B I_{exc} \quad \ldots(12)$$

And of course the vars per unit of active weight may also be obtained by

$$\frac{P_q}{m_1} = \frac{E^2_{(5-6)}}{\omega C_b R_a R_c^{m_1}} = \frac{K_4 B^2}{C_b} \quad \ldots(13)$$

Constants for Routine Testing:

As can be seen from the foregoing, the equations for this modification of the Hay bridge test make it readily adaptable to rapid calculation of test results if the constants are evaluated in advance for the desired test conditions. In fact by choosing suitable values for the ratio arms R_a and R_c, the bridge may be made direct reading for permeability and exciting current. This makes the method very convenient for obtaining magnetic data at 60 cycles, or at other fixed frequencies, and at fixed inductions as most routine magnetic measurements are made. Permeability values will be direct reading in terms of capacitance if the value of the ratio product R_aR_c is such that the constant K_1 in Eq 5 is 10 with some integer exponent. Making $K_1 = 10^4$, when C_b is in microfarads, works out very well for most test conditions. So if

$$R_a R_c = \frac{125.7\, N_1^2 A}{l_1} \quad \ldots\ldots(14)$$

Then

$$\mu_{ac} = C_b 10^4,\ C_b \text{ in } \mu f \quad \ldots(15)$$

The exciting current is made direct reading by making $R_c = 10$ with some integer exponent, also. Then, for routine testing at a fixed induction and frequency, the R_a values, R'_w values, and test voltages will vary directly with the weights of the specimens for a given assumed density; so that if these values are tabulated for small increments of weight, commonly wanted magnetic data are obtained either by direct reading or by one step of multiplication (or division) involving constants which have been calculated in advance for these fixed test conditions.

Equipment for Modified Hay Bridge Test

The modified Hay bridge circuit is capable of giving accurate and reproducible results over a very wide range of test conditions if reasonable care is used in the selection of the circuit components and if proper attention is given to adapt the test procedures to the special requirements imposed by some test conditions. For the sake of clarity, each of the principal components of a desirable, modified Hay bridge installation for magnetic testing will be considered and discussed separately, even though some of the important factors may have been touched on earlier in the general description of the method.

Test Frame:

For testing Epstein specimens, a test frame similar in form to that described in Section 5 of ASTM Methods A 343–49[3] is needed. If testing is to be done only at 60 or 400 cycles, either the standard 25-cm Epstein frame (700 turns) or the 1000-turn test frame currently used for tests by the Owen bridge method will give satisfactory results. Frequencies higher than 1000 cycles call for more careful attention to certain factors in design of the test frame, so a special test frame is desirable for such frequencies.

The choice of a test frame is governed by the specimen size as well as the frequency. It is desirable at all times to work with a reasonably high voltage on the test winding so as to insure freedom from the effects of minute leakage currents and pick-up from stray fields. With lightweight specimens at low inductions and frequencies, a rather large number of turns will be needed in the test winding. At high frequencies, ample voltage may be obtained with fewer turns, but precautions must be taken to minimize the distributed capacitance of the test frame by adhering strictly to a single-layer winding. It is desirable to use stranded wire for the windings if testing is to be done at frequencies near 100 kc or higher. For frequencies of 1 to 20 kc or so, a total of 200 turns is usually suitable for the winding on an Epstein test frame. For higher frequencies, 100 kc or up, 100 turns is a better compromise. In any case, the solenoids should have a cross-sectional area not too much in excess of the average cross-sectional area of the specimens to be tested.

If the foregoing precautions are followed, the test windings will have negligible effects on the measurements of magnetic properties. However, accurate work may still be done with windings that are not ideally suited to the specimen size and test conditions if such imperfections are recognized and compensated for in the circuitry. For instance, if there is a likelihood that the test frame will be used for specimens so small in size, or low in permeability, that the voltage drop in the resistance of the primary winding will be large enough to make a significant error in induction when it is determined from the primary voltage; then a secondary winding should be used to permit the induction to be determined from the voltage measured on the unloaded secondary winding. At relatively low frequencies (less than 5 kc), some use has been made of test frames employing a mutual inductor to fully compensate for air flux within the test winding. In this case the induction values calculated from the secondary voltage will be the intrinsic (or ferric) values.

In some rare cases, where the area of the test specimen is very much smaller than that for which the test windings were designed, the self inductance of the test winding resulting from air flux may be large enough to affect the accuracy of the test results unless the bridge circuit is compensated for such inductance. To accomplish this compensation, a condenser C'_w may be added across bridge arm B (3–4), parallel with R'_w, and of such value that

$$C'_w = \frac{L_w}{R_a R_c},\ \text{microfarads} \quad \ldots(16)$$

where L_w is the self inductance, in microhenrys, of the primary winding, including air flux compensator, if used. In most installations there may never be any need for this compensation; but if required, it may be made by providing an adjustable air condenser having a maximum capacitance of about 1000 μμf paralleling a decade of 1000-μμf units.

[4] Active weight of Epstein specimens is determined as specified in Section 7(b) of ASTM A 343–49.

Resistance and Capacitance Components:

Careful consideration should be given to the selection and use of the resistance and capacitance components in the bridge circuit if high frequency tests are to be made. The decade resistance boxes, necessary for flexibility of adjustment, need to have a very small percentage of reactance at the frequencies of interest. Well-designed resistance boxes may be used at most any value of resistance at low frequencies, but above 10 kc it is desirable to have a minimum of 100 ohms in any resistance arm. At about 100 kc it is preferable that the values of the other parameters of the bridge circuit be of such value that a minimum resistance of about 1000 ohms is employed in any resistance arm of the bridge.

The decade capacitor should be selected to have extremely low losses. A good all-mica unit is most satisfactory. At 60 cycles the higher capacitance units may be high-quality paper condensers, but at frequencies above 1 kc only mica units should be employed. At frequencies near 100 kc the maximum capacitance value in the decade capacitance used should be limited to about 0.1 μf so that higher values of resistance may be used. With these precautions being observed, readily available standard components will impose no serious limitations on the accuracy of the test results.

Detector:

The type of detector to be used will depend upon the induction and frequency range desired from the bridge, and upon the accuracy required. In general, some sort of tuned detector of high sensitivity and high impedance is preferred for all conditions. Balancing for the fundamental frequency is almost essential if accurate tests are to be made at inductions much higher than 1 kilogauss. At low inductions (below 1 kilogauss) a very sensitive vacuum-tube voltmeter makes an adequate balance detector because the harmonic content of the unbalance voltage in the bridge is usually not too high. However, at inductions of 5 to 10 kilogausses at low frequencies, the wave form imposed on the detector is so rich in harmonics that it is impossible to get a sharp balance unless a tuned detector is used. An oscillograph is not a satisfactory balance detector under such conditions, since it is impossible to ascertain visually when the fundamental frequency is of zero amplitude with such complex bridge output wave forms.

For 60-cycle work, a tuned vibration galvanometer is the preferred detector. For audio frequencies, an electronic detector preceded by a filter, or a wave analyzer makes a very satisfactory detector. At supersonic frequencies, where the induction is necessarily low or where considerable magnetic skin effect is manifested, an electronic voltmeter again may be used effectively as a detector without filters since the harmonic content in the bridge output is usually low under such conditions. Whenever an electronic voltmeter is used as a detector, care should be exercised to provide adequate isolation of its power supply from ground.

Power Source:

A power source having excellent voltage and frequency stability is essential for accurate testing. Commercial 60-cycle power lines are rarely stable enough, and voltage-regulated transformers do not have sufficiently sinusoidal wave form. A motor-generator set is ideal for testing at a fixed frequency, but for variable frequency testing an electronic oscillator and power amplifier working from a voltage-regulated transformer is perhaps the best solution of the problem.

A resistance-tuned oscillator with no more than 1 per cent distortion is a good voltage source. An amplifier giving 10 to 50 watts of power at low distortion is needed for wide-range testing. Commercial sound amplifiers usually have serious distortion at low frequencies. Normally, they give acceptable results at 400 cycles and higher at moderate and low test inductions. Sometimes, if a good sound amplifier is equipped with a special output transformer of very generous size for the power to be handled, and with a multiplicity of taps to provide relatively small voltage steps, the wave form at low frequencies may be substantially improved, so that tests may be made at relatively high inductions at low frequencies.

At Armco Research Laboratories, a special amplifier employing 6A5 or 6B4 tubes operating in class A or AB, push-pull parallel, has been found to give excellent wave form from 20 to 40,000 cycles when the coupling transformers were designed to have very high inductive reactance with a minimum of resistance and distributed capacitance. For still higher frequencies, a similar amplifier has been constructed having coupling transformers designed for operation over a frequency range of 5 kc to 200 kc.

Procedure for Magnetic Testing by Modified Hay Bridge Method

When testing at moderate and low frequencies, the values of the ratio arms R_a and R_c can be such as will put the value of capacitance C_b in the best working range. This working range can be from 0.1 to 10 μf at 60 cycles, but should be lower as the frequency is increased. The ratio arms may be of somewhere near equal resistance at low inductions, say up to 1000 gausses; but as the induction is increased it is usually desirable that the value of R_c be low enough so as not to distort the wave form at the test winding.

At Armco Research Laboratories, the practice has been to use 1000 ohms for R_c for routine 60-cycle tests in the 1000-turn test frame at inductions less than 1000 gausses. A resistance of 100 ohms for R_c is usually satisfactory from 1000 gausses to about 5000 gausses, and about 10 ohms is best for still higher inductions at 60 cycles. Whenever R_c is reduced to minimize distortion, R_a is increased so as to keep the product R_aR_c constant. When testing at high frequencies, however, the values of R_a and R_c will have to be kept reasonably high, and C_b somewhat lower than otherwise so as to minimize the effects of unwanted quadrature parameters in these components.

To obtain reproducible test results at low and moderate inductions, it is necessary that the specimen be demagnetized prior to testing. This is preferably done in the same test frame to be used for the tests because it is impossible to handle a specimen of high-permeability material after demagnetizing without polarizing it or disturbing the magnetic condition to an unknown degree. In most cases it will be desirable to wait a short time after demagnetization to allow the low-induction properties to drift to a fairly stable condition.

Demagnetization may be accomplished (referring to Fig. 2) by having switches S_2 and S_3 open, switch S_1 closed, and R_c either shorted or reduced to zero. Then starting with a voltage corresponding to about 14 kilogausses or higher in the test specimen (for silicon-iron alloys and about 50 per cent nickel-iron alloys), the voltage is decreased slowly to some point near zero, or lower than the voltage at the lowest induction point where tests are to be made.

Normal tests at a fixed frequency are then carried out in the following steps:

1. Switch S_2 is closed and the proper value of R_c inserted.

2. The voltage is increased to give the proper value for E_{f-f} for the lowest induction test point, being careful not to exceed the desired voltage setting.

3. Connect detector and balance by alternately varying C_b and R_b until a minimum reading is obtained on the detector. If a sharply tuned detector is used, the balance usually can be adjusted to give a zero reading on the detector.

4. The voltage E across the test winding should be rechecked after

balancing to see whether drift has occurred. If so, some slight readjustments may be needed.

5. Exciting current is measured by reading the voltage across R_c with a vacuum-tube voltmeter.

6. If tests are to be made at higher inductions, steps 2 to 5 are repeated for every increasing induction point.

7. If curves are to be obtained at various frequencies, the specimen should be demagnetized again before proceeding with the tests at the lowest induction for another frequency. It is often desirable to recheck the exciting current at the lowest induction at the frequency just completed to be sure the state of demagnetization is the same before the curve is run at a new frequency.

When curves are run at various frequencies it is sometimes more convenient to work at one induction while the frequency is increased point by point to the maximum frequency. A new curve is then run for the next higher induction value. In this case demagnetization between steps is not necessary, but it will be necessary to allow more time after the original demagnetization to allow drift to proceed to a very stable point.

Incremental measurements are made in a similar manner after demagnetization except that S_3 is closed, the d-c supply voltage is adjusted to give the desired biasing current after which S_3 is reversed several times to establish cyclic conditions. The biasing magnetizing force will be,

$$H_b = \frac{0.4\pi N_2 I_{d-c}}{l_1}, \text{ oersteds (when } I_{dc} \text{ is in amperes and } l_1 \text{ in cm)}$$

Accuracy and Utility of the Modified Hay Bridge Test

The accuracy and utility of this modification of the Hay Bridge have been proved by over two years of wide-range testing of magnetic materials at Armco Research Laboratories. This laboratory is also equipped for accurate core loss measurements at high inductions for frequencies up to 15 kc and at loss levels up to 100 w by the Epstein (wattmeter) method. Experience has shown that when core loss tests at low energy levels are made by the bridge method, and high-level tests by the wattmeter method, the ranges of the methods overlap to a great degree, yet curves obtained on a given specimen by both methods coincide within test error (± 3 per cent) where the overlapping occurs even though the two types of test method differ greatly as to means of calibration. At 60 cycles, with proper attention to test procedures, testing can be carried out from inductions of less than 10 gausses up to 12 or 13 kilogausses on unoriented materials and up to 15 or 16 kilogausses on oriented transformer grades, with good wave form and with accuracy equal to that of the Epstein methods.

Certain precautions are necessary to obtain this high degree of accuracy. First of all, the voltage wave form across the test winding should be nearly sinusoidal. This requires that the value of R_c and the circuit resistance of the power source be quite low compared with the reactance of the test winding containing the material under test when testing at high inductions where the exciting current is badly distorted. If the induction of the test specimen is nearly sinusoidal, and if the voltmeter is calibrated to an accuracy of 1 per cent or better, an accuracy of ± 3 per cent can be achieved for any of the magnetic properties at 60 cycles. The accuracy can be held within ± 5 per cent up to 10 kc if precautions mentioned in the description of the decade resistance and capacitance boxes are also observed. At still higher frequencies (up to 200 kc) the accuracy can be ± 10 per cent or better if recommendations as to components and procedures for such frequencies have been carried out. Even better accuracy can be obtained when the accuracy of the voltmeter used to ascer-

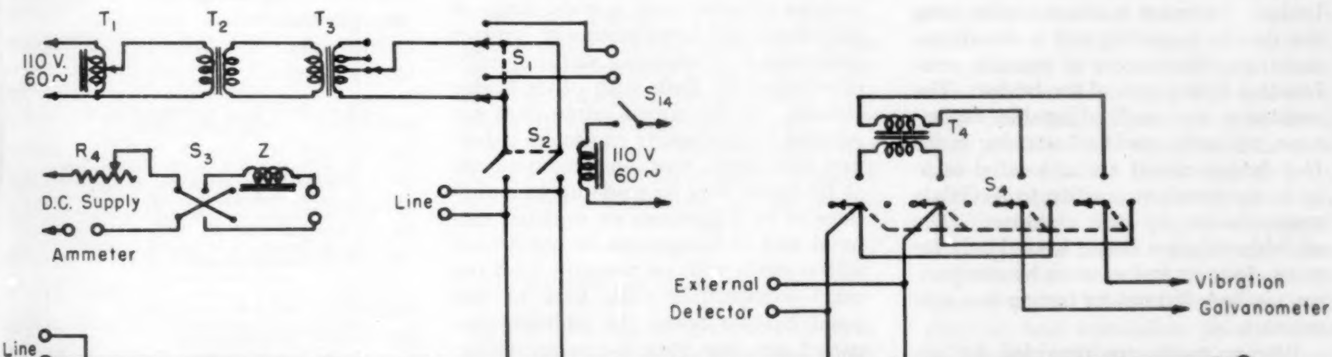


Fig. 3.—Wiring Diagram for the Universal Bridge Equipment.

tain the test induction is better than 1 per cent.

While primarily developed for tests on Epstein samples, the same method and procedures are suitable for testing cores, except that the properties in this case will not be true material characteristics but will include effects due to joints and concentrated windings, where such conditions are present.

Description of Universal Bridge Testing Equipment

In order to make bridge tests in the most rapid and convenient manner, testing apparatus suitable for use as a universal a-c bridge was recently constructed at the Armco Research Laboratories. It incorporates all the components and auxiliaries ordinarily needed for making bridge tests with either 60-cycle power or variable-frequency, electronically generated power. Facilities are also provided for d-c excitation. The circuit diagram of this equipment is shown in Fig. 3, and a parts list is also given. Figure 4 illustrates the arrangement of the parts.

With this arrangement any desired component may be switched into any arm of the bridge circuit to set up any common bridge test in a few seconds. Paralleling of components is easily accomplished by switching the desired components into the same arm of the bridge. Provision is also made for using the decade capacitor and a decade resistor in either series or parallel combination in any arm of the bridge. The resistance box and adjustable capacitance normally used for balancing in the Hay bridge circuit are so located as to be in a convenient position to facilitiate manipulation by the operator. The variable inductor shown is used only for rough tests on inductances by comparison methods but not for testing iron core reactors.

Binding posts are provided for external connections of components in unusual cases. A choice of either vacuum-tube voltmeter or vibration galvanometer as a detector is available. Other types of detectors may be connected externally. Very low resistance wiring and low contact resistance switches are used throughout. The arrangement of components and wiring has been done in such a way that no individual shielding of circuits has been required on this equipment when testing at up to 200 kc. However, care was taken to provide exceptional isolation in power supply circuits. The electronic power equipment and certain auxiliaries, such as the oscillograph and wave analyzer, are mounted on a mobile rack so as not to encumber the set-up unduly when these auxiliaries are not in use.

Fig. 4.—Universal Bridge Equipment in Use for Magnetic Testing of Epstein Samples by Modified Hay Bridge Method. Power source for high-frequency measurements is at right of operator.

Summary

Experiments carried out at Armco Research Laboratories have shown that the Hay bridge circuit, when modified to compensate for copper loss in the test winding, is capable of giving accurate data on magnetic properties of Epstein samples or cores over a wide range of inductions and frequencies with greater convenience of balancing and simplicity of calculations than with other bridge circuits. If the circuit parameters are selected to give nearly sinusoidal induction wave form, core loss measurements at 60 cycles may be made up to inductions of 16 kilogausses on oriented material and 13 kilogausses on unoriented silicon steels with an accuracy (±3 per cent)—comparable with that of the usual Epstein tests. In addition, apparent core loss, vars, a-c permeability, and Q values may be obtained simultaneously with equal accuracy and remarkable ease of calculation from 10 gausses or less up to the high inductions just mentioned.

The method has been found applicable to test at high frequencies (up to 200 kc) with only slightly poorer accuracy when care is taken to provide suitable test windings and bridge components with low quadrature effects. Incremental tests are made easily when the test specimen is equipped with a polarizing winding.

If properly used, the equipment described here is capable of covering the whole range of test conditions normally encountered in the usual a-c applications of magnetic materials, with the exception of the few cases where either the core loss or the apparent core loss is so high (that is 5 w per lb or higher) as to be beyond the current-carrying capacity of the bridge components. More widespread use of the method would seem to be advantageous for routine grading of magnetic materials as well as for developing design data for electrical equipment.

Parts List for Universal Bridge Equipment

T_1 = Variac V-5, V-10 or equivalent,
T_2 = Isolation transformer, 115/115 volts,
T_3 = Special, 115/115/50/25/5/1 volts,
T_4 = Step-down transformer 4:1, Gen. Rad. 578-B,
L_1 = Decade inductor, Gen. Radio 940-D,
Z = Choke, special, 1 henry or higher at max direct current,
R_1 = Decade resistor, Gen. Radio 1432-K, 1432-N or equivalent,
R_2 = Decade resistor, Gen. Radio 1432-N, or equivalent,
R_3 = Decade resistor, Gen. Radio 1432-M, or equivalent,
R_4 = Rheostats for adjusting biasing current, values to suit current and power requirements of test conditions,
R_5 = Decade Resistor, Gen. Radio 1432-P or equivalent,
C_1 = Decade mica capacitor, Gen. Radio 219-K, L & N 1070 or 1071,
C_2 = Fixed capacitor, 1 μf, Gen. Radio 509-Y or equivalent,
S_1 = 2 pole, 2 position switch, 115 volt, 5 amp,
S_2 = A-c relay, 115 volt, 10 amp contacts, low contact resistance,
S_3 = DPDT rocker switch, 125 volt, 30 amp,
S_4 = 4 pole, 3 pos. switch, low contact resistance,
S_5 = 2 pole, 6 pos. switch, low contact resistance,
S_6 & S_{16} = 2 pole, 2 pos. switches, low contact resistance,
S_7 thru S_{12} = 2 pole, 5 pos. switches, low contact resistance,
S_{13} = 6 pole, 3 pos. switch, low contact resistance,
S_{14} = *SPST* switch, 115 volt, 3 amp,
Vibration galvanometer = L & N 2350-a, together with No. 2100 lamp and scale assembly,
VTVM = Ballantine 300, 310A or 302B electronic voltmeter.

The Development of X-Ray Standards for Shielded Arc Welds in Aluminum

By J. J. Hirschfield,[1] D. T. O'Connor,[1] J. J. Pierce,[1] and D. Polansky[1]

SYNOPSIS

A set of X-ray standards for shielded arc welds in aluminum has been established on the basis of guided bend and tension tests of 300 specimens. Agreement between the two types of tests was good. It was concluded that all grades of incomplete penetration, dross, and cracks should be considered rejectable, that scattered porosity and tungsten inclusion do not significantly reduce strength, and that the intermediate and more severe grades of linear porosity and gas holes should be considered rejectable. A book of film standards has been prepared incorporating a summary of the test data. Although the specimens were prepared by Heliarc welding of ¼-in. S3 aluminum plate over a grooved steel back-up bar, the standards are intended to apply to all similar types of shielded arc welding in 2S and 3S aluminum plate and particularly to mine case welds.

DURING the Summer of 1949 a Bureau of Ordnance contractor experienced certain difficulties in securing satisfactory welding in aluminum mine cases which they were producing under Bureau of Ordnance contract. These cases were inspected under Ordnance Specifications prepared by the Naval Ordnance Laboratory. X-ray examination of production weldments conducted by representatives of the Naval Ordnance Laboratory in the manufacturer's plant demonstrated that visual inspection was inadequate and failed to insure the acceptance of sound welds. Accordingly the Underwater Ordnance Department of the Naval Ordnance Laboratory requested that there be prepared a set of radiographic standards for use in the inspection of aluminum mine case welds (shielded arc process).

Before beginning any experimental work directed toward the establishment of standards for aluminum mine case welds, a survey was made of existing standards or codes. Inquiry by personal contact or by letter was made of several organizations.

The only positive response came from the Casting, Weldments and Forgings Section of the Bureau of Ships which has prepared a radiographic standard for acceptance of semiautomatic inert-gas shielded metal arc welding of 61ST-6 aluminum. It represents the minimum acceptable quality of an aluminum back-up strip butt weld made in any position including the overhead position. It was decided that this standard was not entirely satisfactory for mine case welds for the following reasons:

1. The material of the Bureau of Ships standard 61ST-6 is considerably different from the mine case, 3S aluminum.
2. The mine case requires a weld which presents a smooth unbroken surface to the explosive filling. The permanent back-up strip butt weld presents two crevices along the back strip which can contain and pinch the explosive filling. A nonpermanent steel or copper back-up strip must be employed to produce a smooth bottom bead. This alters the weld image appreciably.
3. The Bureau of Ships standard represents a minimum quality expected for shipyard conditions, not shop production.

EXTENT OF INVESTIGATION

Since the initial problem of weld quality arose with the mine case which is fabricated of 3S aluminum, it was decided to limit the first effort in the development of weld standards to this material. Shielded arc welding alone was employed. The shielded arc welds are intended to include welds made by the Heliarc or tungsten arc, Aircomatic, and atomic hydrogen welding processes. Radiographically and metallurgically they are sufficiently similar for a common standard.

A severe limitation on time was imposed in order that a standard be available as quickly as possible. Working time was further reduced by the delay in obtaining material and equipment and funds were limited.

Accordingly a minimum program was planned:

1. An investigation and review of existing radiographic standards of aluminum welds.
2. Shop work for preparation of approximately 100 weld samples and the collecting of existing samples.
3. Radiography and selection of specimens.
4. Specimen preparation for bend and tension tests.
5. Metallography.
6. Physical tests.
7. Correlation of radiographic, bend, and tension tests.
8. Setting up of a tentative standards selection based on test data, survey, and design requirements.

CRITERIA FOR STANDARDS SELECTION

The basic criterion for standards selection is the correlation of the strength of welds with their X-ray images. Owing to the need to prepare and follow a minimum program involving a relatively small number of test specimens, it was felt that positive, unequivocal correlation was not assured. Since a usable even though imperfect standard was required in a relatively short time, two additional criteria for selection were proposed. These were an arbitrary quality level determined from a survey of existing mine cases and an arbitrary quality level based on design requirements. The quality survey of existing cases has not been completed and therefore was not considered in this study. The radiographic and physical test correlation results were sufficiently positive so that no reliance had to be placed on arbitrary ill-defined requirements. Rather, design requirements can now be defined in terms of the physical tests.

X-ray examination of shielded arc welds in 3S aluminum can be expected to be a very sensitive index of weld quality. There is no question of the dubious effects of heat treatment, burning, or other metallurgical phenomena which might reduce weld strength. The reason for this fortunate situation is that there is virtually no zone of transition between the weld and parent metal. In this type weld the zone is actually a line, as will be demonstrated. Therefore, only the physical characteristics of the weld need be considered. These physical characteristics are completely revealed in X-ray examination.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] U. S. Naval Ordnance Laboratory, White Oak, Md.

Preparation of Weld Specimens

Materials and Equipment:

All specimen welds were run in 3S aluminum plate $\frac{1}{4}$ in. thick. This is the material used for the mine cases. Each specimen was made by butt welding two 5 by 9-in. halves to form a 9 by 10-in. plate.

Three different types of welding rod were used: 43S, 2S, and 43S coated rods from which the coating was knocked off before use. Both the $\frac{1}{8}$ and $\frac{3}{16}$-in. sizes of the uncoated rods and the $\frac{5}{32}$ in. size coated rods were employed.

A Westinghouse Flexarc a-c Welder Serial No. 4634 Style No. 1457111 was employed for all specimen welds made in the laboratory. This is a double, high-frequency transformer Heliarc welder with a current maximum of 400 amp.

A small angle-iron welding jig incorporating a steel back-up bar was constructed for the welding operation.

Physical Arrangement:

Special provisions had been made to permit the welding operations to be carried on in the X-ray laboratory. Close cooperation between the welder and the radiographer was possible and proved to be very fruitful. Early viewing of specimens gave the welder considerable control over the quality of his output. The grooved back-up bar was beneath the butted edges of the half plates which were held securely by clamps. The welding fixture permitted the use of dry ice beneath the plates for prechilling. Auxiliary oxyacetylene equipment was available for preheating.

Welding Techniques:

A wide variety of welding procedures was employed in an effort to obtain the required range of defects. No attempt is made to indicate how the technique variables affected weld quality. In all cases the newly welded plates were cooled shortly after welding by immersion for a few minutes in a pail of water.

The defects of incomplete penetration, dross, and tungsten inclusions were easily obtained by the welder. To obtain the other defects the amperage was varied from 165 amp to 370 amp with most of the readings between 185 and 300. The argon flow varied from 4 to 15 liters per min while the time of welding varied from 2 to 12 min. Preheating and chilling of the plates were other variables. The plates were X-rayed soon after they were welded so that the defect could be classified and the welding technique either changed or possibly repeated to obtain a few more grades. The difficulty in obtaining the defects of linear porosity, scattered porosity, and the various kinds of cracks may be appreciated from the diversity of the variable factors used in the welding.

Identification and Selection:

As soon as practicable after welding, the plates were identified with metal die-stamped numbers from 1 to 142. On the basis of the radiographs of each plate, 2 and $\frac{3}{4}$-in. wide strips taken transverse to the weld were scribed across the plate. The plate number and a code letter were stamped on each strip. This number was placed on the $\frac{1}{4}$-in. end of the tension strips. After machining into strips, the identification was checked by radiography again and a second code letter added to indicate the type of physical test to be used. This code was used for brevity in identification and handling as follows:

Code	Defect
A	Incomplete penetration
B	Dross stringers
C	Linear porosity
D	Scattered porosity
E	Gas holes
G	Crater cracks
H	Transverse cracks
J	Longitudinal cracks
K	Tungsten inclusions
F	Face bend test
R	Root bend test
T	Tensile strength test

Some of the test code letters have a subscript. This merely indicates that more than one strip containing a given defect was destined for the same type test. The preliminary selection or classification is therefore given by the first code letter. As may be noted in later tables, the preliminary classification had to be changed in a few cases due to the defects being contained in the machined-off part or the change in the relative importance of grades of two types of defects occurring in the same specimen.

This study is concerned with nine different types of defects which occur in the shielded arc welding of aluminum. The nine defects are incomplete penetration, dross stringers, linear porosity, scattered porosity, gas holes, crater cracks, transverse cracks, longitudinal cracks, and tungsten inclusions. These terms are common to the literature and need no further definition.

In the establishment of a set of standards of the defects that usually occur in shielded arc welding, it was arbitrarily decided that there would be five grades of each defect. In grade 1 the defect was of the smallest degree while in grade 5 the defect was the largest that was obtained.

Of the 213 specimens tested and reported on, the question may be raised why there was not a greater number of grades 1 and 2 in any defect. The answer to this lies in the great difficulty in obtaining these low grades in a weld defect. One hundred forty-two plates were viewed with root bend, face bend, and tension test specimens cut from the plates. Since only 12 per cent of the specimens tested were of grades 1 and 2, one may regard this as the frequency of occurrence. To express it another way, one can say that a weld defect will be in grades 3, 4, or 5 about 90 per cent of the time. Time and cost, therefore, were prohibitive factors in the attempt to have more specimens in grades 1 and 2.

Radiography:

All specimens were radiographed at 60 kv using Picker 150-kvp apparatus employing a 2.5-mm focal spot Machlett Thermax tube at a distance of 6 ft. Eastman Kodak Type M film in plain cardboard holders was used in all cases. Processing was standard except that X-Ray Microdol Developer[2] was used in order to obtain images of optimum quality. Each sample plate was radiographed with a penetrameter and penetrameter block to insure uniform and adequate sensitivity through the full bead thickness.

Machining:

The original sheets of $\frac{1}{4}$-in. 3S aluminum were 36 by 96 in. The half plates were sheared from this stock size. A few of the specimen welds were made with V-groove preparation but since welds were easily made without any edge preparation, none was used generally.

The machining was done by the Technical Shop. The first operation, cutting the plates into strips, was done on a band saw because the weld bead prevented the use of the shears. This operation was poorly done, the cuts being quite irregular. The weld bead was to have been removed by grinding, but this proved unsatisfactory. Instead an end milling operation was used. A slight dihedral angle due to the welding process prevented thickness uniformity between the weld and plate metal. The machined surfaces of the bend test specimens were trued reasonably well by a hand filing operation. The burrs were removed from these pieces and the corners and sharp edges broken by another filing operation.

Since additional machining was required on the tension test specimens, it was decided to reduce the thickness by $\frac{1}{16}$ in. over the gage length in order to eliminate spurious effects due to imperfect surface conditions. The maximum deviation in cross-sectional area as determined from measurements on 12

[2] D. T. O'Connor, "The Radiography of Captured Enemy Equipment," *Industrial Radiography*, Vol. 5, Winter 1946, pp. 6–10.

specimens was 3.6 per cent. The machining of the tension test specimens was done in accordance with Federal Specifications[3] for the preparation of such samples.

The cross-sectional area of the tension test specimen was 0.109 sq in.

Selection of Tests

Of all the guides to be used in selecting physical tests for correlating defects in material with material strength probably the most obvious is economy. For instance, the use of dynamic tests to evaluate fatigue characteristics or serviceability for well-defined loadings is obviously more expensive than a simple static tension or compression test. For reasons already given it was decided for this study to employ only simple static tests for correlation purposes.

The tension test was chosen for two reasons: it is the classical index of material strength relied upon by engineering designers, and it has frequently been used in the past for casting strength X-ray correlations.

The guided bend test was chosen because it is the basis of the qualification test for metal arc welders as outlined in Federal Specifications.[4] Although no previous reports of attempts at correlating bend test results with radiography have been noted, encouraging reference is made in the literature[5] to this possibility.

The guided bend tests were carried out in accordance with the directions given in Appendix VII of the General Specifications.[6] The bending force was applied in a hydraulic press. This is a go, no-go test. Broken specimens, or any in which an opening or crack exceeding $\frac{1}{8}$ in. in any direction appears, are rejectable.

The tension specimens were pulled in a 20,000-lb hydraulic Universal Testing Machine, Model 20-35 as manufactured by the Baldwin Southwark Division of the Baldwin Locomotive Works. The rate of loading was 2,000 lb per min. Gage marks or points were taken 1 in. apart including the weld in order that the measured elongation might be more representative of the weld metal than would have been the case had a 2-in. gage length been taken. The data taken were breaking load or ultimate strength and elongation.

Results and Discussion of Bend Tests:

Fifty-seven strips graded incomplete penetration were tested (refer to Table I). Five strips, two of grade 3, two of grade 4, and one of grade 5, passed the face bend test. It was noted that strips cut from the same plates passed the face bend test and failed in the root bend test. For example, strip 4AF, grade 5, passed the face bend test while strip 4 AR, also grade 5, failed in the root bend test. This can be readily understood upon visual examination of the weld. Since the lack of penetration is at the root of the weld, this section of the weld undergoes compression in the face bend test. Thus the possibility exists that some cases of severe lack of penetration may pass the face bend test. Fifteen per cent of the strips given the face bend test passed while no strip passed the root bend test.

TABLE I.—RESULTS OF GUIDED BEND TESTS ON GRADES OF INCOMPLETE PENETRATION, ASTM 6.1.*

	Test	Pass	Fail
Grade 1........	Face	.	1
	Root	.	..
Grade 2........	Face	.	1
	Root	.	..
Grade 3........	Face	2	2
	Root	.	2
Grade 4........	Face	2	2
	Root	.	4
Grade 5........	Face	1	16
	Root	.	14

* Code Numbers such as ASTM 6.1, ASTM 6.32, etc., refer to the defect classification as outlined in ASTM Terminology E 52 – 49 T.[3] and used in this paper for classification of defects in the aluminum welds.

The results of the physical tests indicate that all grades of incomplete penetration are unsatisfactory.

Of the 58 strips tested, classed as dross, 9 passed the face bend test while none passed the root bend test (refer to Table II). As in the tests of incomplete penetration it was noted that a strip, for example 94 BF, would pass the face bend test but another strip of the same grade, 94 BR, would fail in the root bend test. Perhaps a better example would be strip 104 BF grade 4 that passed the face bend test while strip 104 BR grade 1 failed in the root bend test. The study of Table II indicates that the root bend test is the more critical test of the two.

TABLE II.—RESULTS OF GUIDED BEND TESTS ON GRADES OF SLAG-OXIDE, ASTM 6.4.

	Test	Pass	Fail
Grade 1........	Face	.	2
	Root	.	6
Grade 2........	Face	.	1
	Root	.	3
Grade 3........	Face	5	2
	Root	.	5
Grade 4........	Face	2	2
	Root	.	6
Grade 5........	Face	2	10
	Root	.	12
	Total	9	49

Since all strips failed in the root bend test and as there are examples of strips in all grades that failed in the face bend test, the tests show that all grades of welds showing dross are unsatisfactory.

Thirty-five strips, grades linear porosity, were tested (refer to Table III.) All the specimens graded 1 and 2 passed. Thirty per cent of the strips in grade 3 passed.

The tests show that welds with linear porosity of grades 1 and 2 are satisfactory while all welds of grades 3, 4, and 5 are unsatisfactory.

Of the 33 strips graded scattered porosity none failed in either of the bend tests (refer to Table IV). This means that welds with scattered porosity of any grade from 1 to 5 are satisfactory.

As has been previously indicated, occasionally there has been a change in the classification of a strip. The ones that have been changed from scattered porosity to linear porosity were due to an error in the preliminary classification. Of special interest though are the ones that were changed from scattered porosity to dross. It was noted that in each grade of scattered porosity there was one failure in either the face bend or root bend test or in both tests. Upon further examination it was found that all those that had failed had traces of dross in the strip in various degree that extended from a trace of dross up to grade 1 dross. Therefore, although all grades of scattered porosity are satisfactory in welds, any trace of dross in a strip immediately changes the classification to dross of which all grades are unsatisfactory.

TABLE III.—RESULTS OF GUIDED BEND TESTS ON GRADES OF LINEAR POROSITY, ASTM 6.32.

	Test	Pass	Fail
Grade 1........	Face	3	..
	Root	.	..
Grade 2........	Face	3	..
	Root	1	..
Grade 3........	Face	2	3
	Root	.	2
Grade 4........	Face	.	3
	Root	.	4
Grade 5........	Face	1	5
	Root	.	8
	Total	10	25

TABLE IV.—RESULTS OF GUIDED BEND TESTS ON GRADES OF SCATTERED POROSITY, ASTM 6.31.

	Test	Pass	Fail
Grade 1........	Face	8	..
	Root	3	..
Grade 2........	Face	4	..
	Root	6	..
Grade 3........	Face	3	..
	Root	1	..
Grade 4........	Face	1	..
	Root	..	..
Grade 5........	Face	3	..
	Root	4	..
	Total	33	0

[3] General Specifications for Inspection of Material, Appendix II, Metals Part A Definitions and Tests Issued by the Navy Department, April 1, 1947.

[4] General Specifications for Inspection of Material, Appendix VII Welding Part E-1, Qualification Tests for Metal Arc Welders, Issued by the Navy Department March 15, 1943.

[5] L. W. Ball, "Some Calibration Data and Scatter Measurements for the Radiography of Magnesium Aircraft Castings," Symposium on Radiography, Am. Soc. Testing Mats. Discussion, H. H. Lester, p. 138 (1943) (Symposium issued as separate publication, *STP No 28 A*).

[6] General Specifications for Inspection of Material, Appendix VII Welding Part E-1, Qualification Tests for Metal Arc Welders, Issued by the Navy Department, March 15, 1943.

Nineteen strips graded gas holes were tested (refer to Table V). All those in grades 1 and 2 passed. In the grades from 3 to 5 inclusive, the failures ran from 50 to 80 per cent of those tested.

Therefore welds with gas holes of grades 1 or 2 are satisfactory and gas holes of grades 3, 4, or 5 are unsatisfactory.

TABLE V.—RESULTS OF GUIDED BEND TESTS ON GRADES OF GAS HOLES ASTM 6.33.

	Test	Pass	Fail
Grade 1........	Face	2	..
	Root	1	..
Grade 2........	Face	1	..
	Root	.	..
Grade 3........	Face	2	1
	Root	.	1
Grade 4........	Face	1	3
	Root	.	1
Grade 5........	Face	2	1
	Root	.	3
	Total	9	10

Difficulty was experienced in obtaining welds containing cracks; therefore, only three strips graded longitudinal cracks were tested. All three, one of grade 1, one of grade 3, and one of grade 4 failed. The three kinds of cracks, longitudinal, transverse, and crater, in any grade are generally considered unsatisfactory.

Eighteen strips originally graded as having tungsten inclusions were tested. Seven of the strips, covering all five grades, passed. Of the eleven strips that failed it was observed that dross was present in all cases. As reported before in the paragraphs under dross and scattered porosity and repeated here for emphasis, the presence of dross in any weld with any other defect requires the classification of the defect to be dross.

Therefore the presence of tungsten inclusions in a weld from any grade from 1 to 5 without the presence of dross is classed as satisfactory. Machinability is of course very adversely affected by such inclusions.

Results and Discussion of Tension Tests:

In order to obtain a guide for evaluating the results of the tension tests, eight sound weld tension specimens were prepared.

Averaging the results of eight tension tests on these specimens it was found that the breaking load was 1825 ± 90 lb (refer to Table VI) and elongation was 11 per cent; in all these cases the specimen under tension broke in the parent metal, clearly indicating that the weld was stronger than the native metal.

Subsequent tests indicated that the breaking load varied ±275 lb with the break occurring in the parent metal. The criterion for success therefore is a breaking load of 1825 ± 275 lb, elongation 11 ± 2 per cent, and a break in the parent metal. If the specimen under test did not meet all three requirements it was classed as a failure.

TABLE VI—RESULTS OF TENSION TESTS ON SOUND WELDS

Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
6 T....	Good	1840	11	Parent metal
27 T....	Good	1790	10	Parent metal
29 T....	Good	1795	10	Parent metal
90 CT..	Good	1755	13	Parent metal
41 CT..	Good	1845	17	Parent metal
66 CT..	Good	1725	11	Parent metal
21 DT..	Good	1885	10	Parent metal
40 DT$_2$.	Good	1780	10	Parent metal

Twenty-one samples of incomplete penetration were tested and all pieces failed in the welded section under various loads (refer to Table VII). The breaking load varied from 465 to 1350 lb with elongation varying from 2 to 5 per cent. Although no specimen in grade 1 was tested it is clear that none of the specimens tested approached the values found for a good weld (Table VI). The results of this test indicate that all grades of incomplete penetration are classed as unsatisfactory. This result is in agreement with the conclusions reached on the face bend and root bend tests.

Sixteen samples graded dross were tested with the result that the breaking load varied from 705 to 1850 lb, the elongation varied from 7 to 26 per cent. Some strips broke in the weld and others in the metal (refer to Table VIII). Using the results of the test on the good welds as a criterion, that is, a breaking load of 1825 ± 90 lb, an elongation of 11 ± 2 per cent and fracture in the base metal, it is found that all the specimens of grade 1 passed. Seventy-five per cent in grade 2 failed, 65 per cent in grade 3 failed, and all other specimens below grade 3 failed. This indicates that a grade 1 defect in dross would be an acceptable weld and all other grades would be rejectable. This result is not in complete agreement with the results of the face and root bend tests where it was found that all grades of dross are rejectable.

Eight specimens graded linear porosity were tested and all specimens graded 3, 4, and 5 failed (refer to Table IX). In grade 2, 65 per cent of those tested failed. No specimens of grade 1 were available for testing. Since the percentage of failure in grade 2 was so high it will be assumed that a fairly high percentage of grade 1 also would have failed. One can say, therefore, that the tension test indicates that all grades of linear porosity are rejectable. Here the

TABLE VII.—RESULTS OF TENSION TESTS ON GRADES OF INCOMPLETE PENETRATION ASTM 6.1.

Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
46 AT .	4	770	3	Weld metal
4 AT$_2$.	5	740	3	Weld metal
13 AT$_2$.	5	550	3	Weld metal
79 AT .	5	635	3	Weld metal
4 AT$_1$.	5	800	4	Weld metal
81 AT$_2$.	3	1300	5	Weld metal
108 AT$_1$.	3	980	5	Weld metal
3 AT .	4	560	3	Weld metal
11 AT$_3$.	4	645	3	Weld metal
11 AT$_2$.	5	555	3	Weld metal
23 AT .	4	710	4	Weld metal
11 AT$_1$.	5	760	4	Weld metal
16 AT .	5	540	3	Weld metal
81 AT$_1$.	2	1140	4	Weld metal
13 AT$_1$.	5	685	3	Weld metal
41 AT .	5	730	5	Weld metal
2 AT .	3	1375	5	Weld metal
40 AT .	4	970	5	Weld metal
114 AT .	5	465	2	Weld metal
13 AT$_3$.	5	565	2	Weld metal
108 AT$_2$.	3	875	3	Weld metal

TABLE VIII.—RESULTS OF TENSION TESTS ON DROSS, ASTM 6.4.

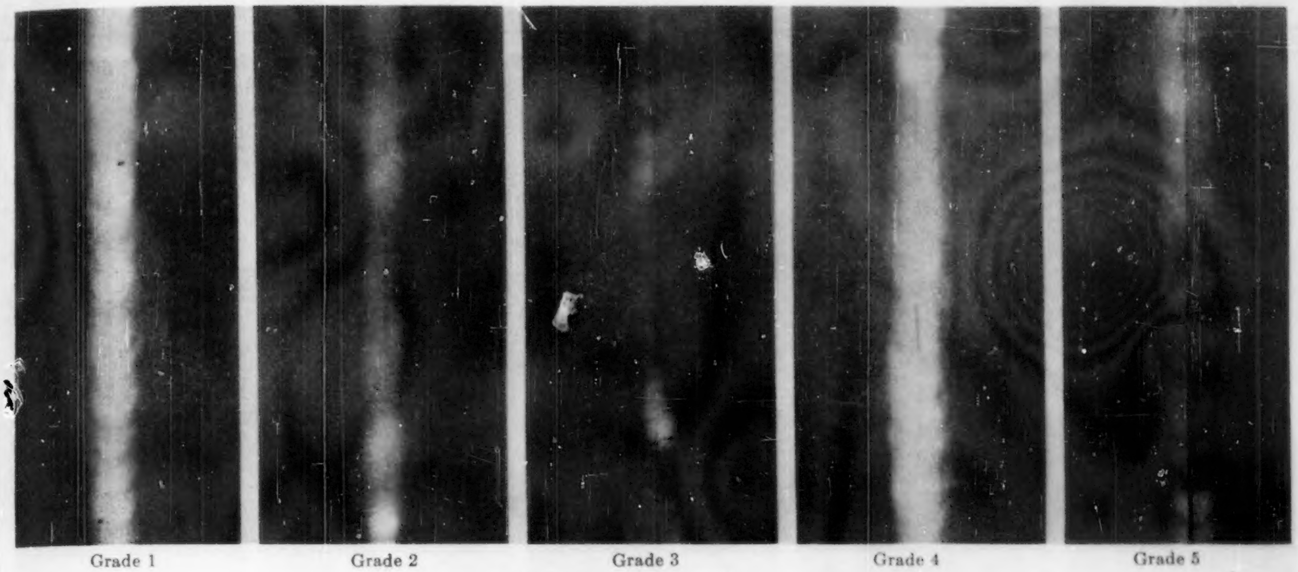
Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
88 BT .	2	1740	16	Weld metal
95 BT .	2	1500	12	Weld metal
104 BT .	1	1845	15	Parent metal
84 BT$_2$.	1	1790	15	Parent metal
105 BT$_1$.	3	1670	15	Weld metal
31 BT .	2	1580	12	Weld metal
39 BT .	5	1300	8	Weld metal
83 BT$_2$.	2	1630	11	Weld metal
84 BT$_3$.	1	1800	15	Parent metal
102 BT .	1	1765	26	Weld metal
84 BT$_1$.	1	1820	20	Weld metal
83 BT$_1$.	1	1775	10	Parent metal
32 BT .	5	1265	7	Weld metal
86 BT$_2$.	3	705	6	Weld metal
86 BT$_1$.	1	1800	11	Parent metal
82 AT .	3	1785	22	Parent metal

TABLE IX.—RESULTS OF TENSION TESTS ON LINEAR POROSITY, ASTM 6.32.

Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
107 CT.	5	685	5	Weld metal
104 CT.	5	1400	7	Weld metal
12 CT.	2	1490	8	Weld metal
129 CT.	5	995	4	Weld metal
28 CT.	2	1610	14	Weld metal
87 CT.	4	925	4	Weld metal
14 CT.	3	1650	13	Weld metal
72 CT.	2	1800	13	Parent metal

lack of correlation with the face and root bend tests is greater as grades 1 and 2 were declared acceptable in the face and root bend tests.

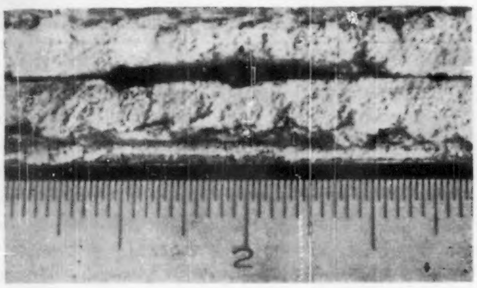
Fifteen strips graded scattered porosity, were tested (refer to Table X). It is noted that all strips broke in the parent metal. Sixty per cent of the strips had a breaking load that was on the average about 10 per cent below the originally accepted value, which is 1825 ± 90 lb. The test apparently indicates that the presence of scattered porosity weakened the parent metal. This conclusion is not very logical; therefore one

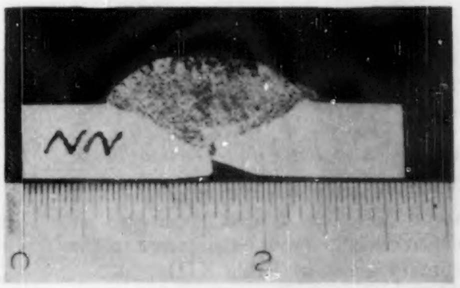


Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

INCOMPLETE PENETRATION, ASTM 6.1.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Bend Test				
100% Failed Rejectable	100% Failed Rejectable	67% Failed Rejectable	75% Failed Rejectable	97% Failed Rejectable
Tension Test				
% U. S. % Elongation Rejectable	60% U. S. 4% Elongation Rejectable	60% U. S. 4% Elongation Rejectable	39% U. S. 3% Elongation Rejectable	36% U. S. 3% Elongation Rejectable





concludes that the standard based on the good welds is too high in regard to the breaking load. Since all the strips broke in the parent metal the standard breaking load should be given a variation of 15 per cent, that is 1825 ± 275 lb. As a result of the tension test all grades of scattered porosity appear acceptable. This is in complete agreement with the conclusions based on the face and root bend tests.

In the test on specimens classified as having gas holes, grades 1 and 2 met the standard as having passed. No specimen of grade 3 was available for testing. Thirty per cent of grade 4 and 50 per cent of grade 5 failed. One can reasonably assume from the above results that there would be some failures in grade 3.

The tension test therefore shows that welds of grades 1 and 2 in gas holes would be acceptable while grades 3, 4, and 5 would be unacceptable.

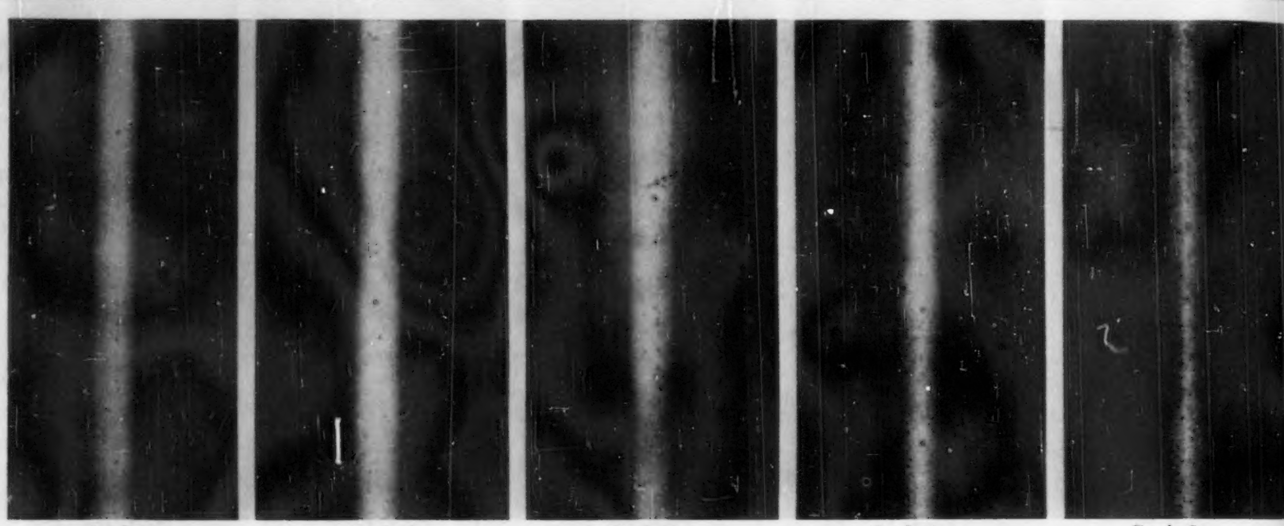
TABLE X.—RESULTS OF TENSION TESTS ON SCATTERED POROSITY, ASTM 6.31.

Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
45 DT ..	3	1795	11	Parent metal
71 DT ..	2	1790	8	Parent metal
18 DT ..	2	1845	6	Parent metal
106 DT_1..	2	1840	10	Parent metal
76 DT_1..	5	1665	18	Parent metal
76 DT_2..	5	1715	12	Parent metal
59 DT ..	1	1750	8	Parent metal
77 DT ..	4	1570	10	Parent metal
69 DT_1..	1	1705	9	Parent metal
78 DT_2..	4	1685	14	Parent metal
61 DT ..	1	1795	9	Parent metal
65 DT ..	2	1670	6	Parent metal
64 DT ..	1	1700	6	Parent metal
117 CT ..	1	1730	10	Parent metal
67 CT ..	2	1570	14	Parent metal

A few plate strips containing cracks were intended for tension specimens; however, the cracks were removed in the machining required for specimen preparation. Therefore no tension data on cracks were obtained. However, it is believed that experience is sufficiently strong to warrant the classification of all

TABLE XI.—RESULTS OF TENSION TESTS ON GAS HOLES, ASTM 6.33.

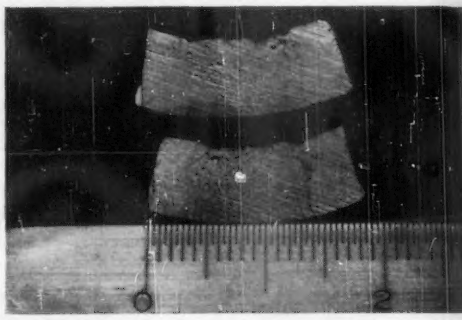
Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
112 ET.	1	1800	13	Parent metal
100 ET.	4	1515	14	Weld metal
80 ET.	5	1340	7	Weld metal
132 ET.	5	1480	8	Weld metal
139 ET.	4	1605	12	Weld metal
116 ET.	5	1805	13	Parent metal
136 ET.	4	1770	12	Parent metal
118 ET.	5	1720	13	Parent metal
63 ET.	2	1755	9	Parent metal



Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

SCATTERED POROSITY, ASTM 6.31.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
		BEND TEST		
0% Failed Acceptable	0% Failed Acceptable	0% Failed Acceptable	0% Failed Acceptable	0% Failed Acceptable
		TENSION TEST		
95% U. S. 8% Elongation Acceptable	95% U. S. 9% Elongation Acceptable	98% U. S. 11% Elongation Acceptable	89% U. S. 12% Elongation Acceptable	92% U. S. 15% Elongation Acceptable



types and grades of cracks as unsatisfactory.

Comparison of Bend and Tension Tests:

The results of the guided bend and tension tests on graded specimens of defective welds may be compared in the summary given in Table XIII.

If it is agreed that all grades of all types of cracks are unacceptable, it may be noted from Table XIII that all grades of incomplete penetration, crater cracks, and transverse cracks are unacceptable. All grades of scattered porosity are acceptable. The results of the two tests differ slightly in the classification dross, where a grade 1 was found acceptable in the tension test and

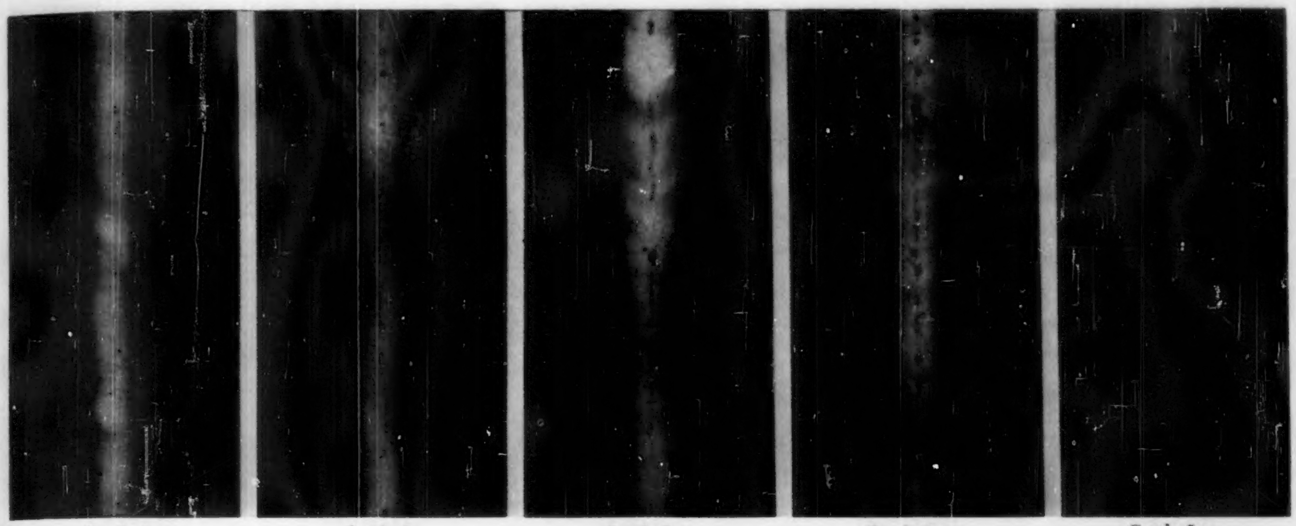
TABLE XII.—RESULTS OF TENSION TESTS ON TUNGSTEN INCLUSIONS, ASTM 6.41.

Strip	Grade	Breaking Load, lb	Elongation, per cent	Location of Break
42 KT .	2	1665	15	Weld metal
105 KT_3.	5	1670	15	Weld metal
50 KT_1.	5	1770	9	Parent metal
21 KT .	4	1820	10	Parent metal
33 KT .	1	1820	11	Parent metal
1 KT_2.	2	1755	11	Parent metal
1 KT .	5	1425	6	Weld metal
137 KT .	1	1800	14	Parent metal
119 KT_1.	3	1785	7	Parent metal
19 KT .	4	1780	7	Parent metal
119 KT_2.	5	1415	9	Weld metal

a grade 1 unacceptable in the face and root guided bend tests. The acceptability of grade 1 dross is therefore dependent primarily upon the direction of the stresses to be applied to the material. Similarly, in linear porosity, grades 1 and 2 are unacceptable for material that will be subjected to tensile stresses while grades 1 and 2 will be acceptable in material in which the stresses will be perpendicular to the plate. In material which is to be subjected to tensile stress and stresses perpendicular to the plate, all grades of dross and linear porosity should be classed as unacceptable. For gas holes, grades 1 and 2 are acceptable in both tests. Tungsten inclusions apparently have little effect on

TABLE XIII.—COMPARISON OF THE RESULTXS OF BEND AND TENSION TESTS.

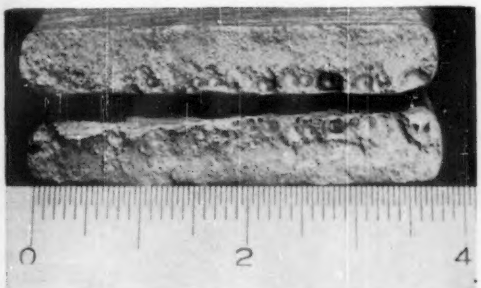
Grade	Incomplete Penetration	Dross	Linear Porosity	Scattered Porosity	Gas Holes	Cracks, Crater	Cracks, Transverse	Cracks, Longitudinal	Tungsten Inclusion
					TENSION TEST				
1....	....	Acceptable	....	Acceptable	Acceptable	....	....	....	Acceptable
2....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Acceptable	....	....	....	Acceptable
3....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Unacceptable	....	....	....	Acceptable
4....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Unacceptable	....	....	....	Acceptable
5....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Unacceptable	....	....	....	Unacceptable
					BEND TEST				
1....	Unacceptable	Unacceptable	Acceptable	Acceptable	Acceptable	....	....	Unacceptable	Acceptable
2....	Unacceptable	Unacceptable	Acceptable	Acceptable	Acceptable	....	....	....	Acceptable
3....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Unacceptable	....	....	Unacceptable	Acceptable
4....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Unacceptable	....	....	Unacceptable	Acceptable
5....	Unacceptable	Unacceptable	Unacceptable	Acceptable	Unacceptable	....	....	....	Acceptable

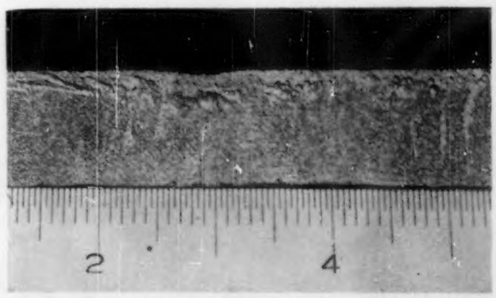


Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

LINEAR POROSITY, ASTM 6.32.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
		BEND TEST		
0% Failed Acceptable	0% Failed Acceptable	71% Failed Rejectable	100% Failed Rejectable	93% Failed Rejectable
		TENSION TEST		
% U. S. % Elongation Rejectable	90% U. S. 12% Elongation Rejectable	90% U. S. 13% Elongation Rejectable	50% U. S. 4% Elongation Rejectable	56% U. S. 5% Elongation Rejectable





weld strength, at least up to grade 5.

PREPARATION OF X-RAY STANDARDS

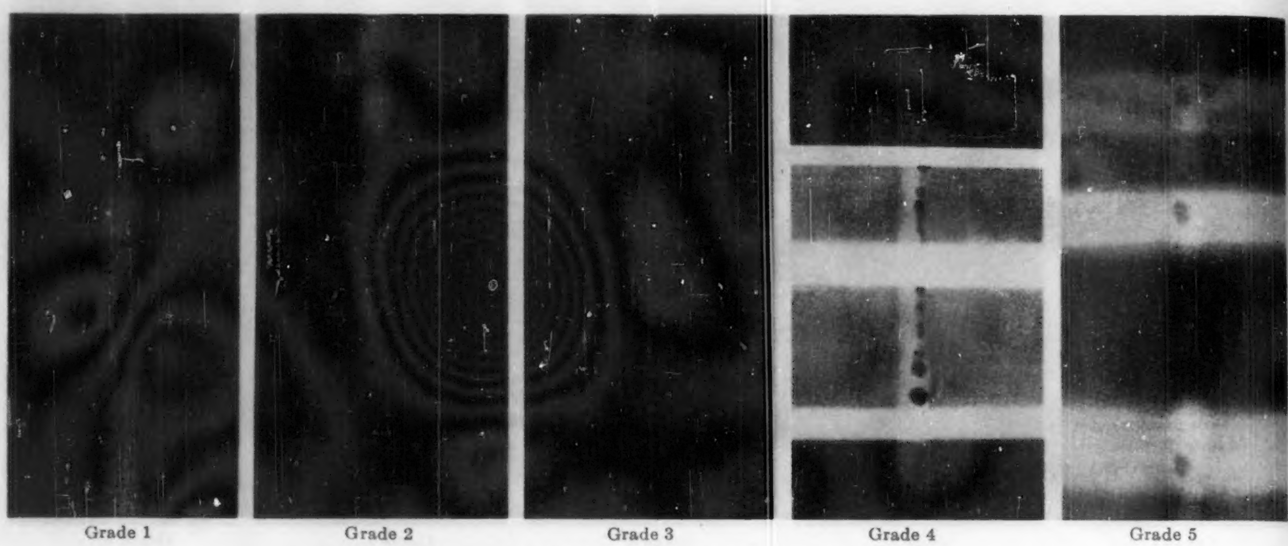
Films to represent the arbitrarily defined grades 1 to 5 of the nine types of defects were selected for the most part from the specimens prepared as described. The original radiographs made before machining were used. In a few cases it was necessary to use other films; this was true particularly for the defects the welder had difficulty in obtaining. These grades were selected from films of about 200 ft of butt welding on actual mine cases. It is for this reason that some of the standard films, all of which are reproduced completely in the Appendix, show reinforcing ribs superimposed on the weld proper, for instance, in grades four and five of gas holes ASTM 6.33. The same criterion for grade selection was used, namely that grade 1 is the smallest and grade 5 the largest or most severe typical defect obtainable, while grades 2, 3, and 4 are intermediate grades. The effort to find standard 4-in weld strips which contained no defect except the one under consideration was not always successful. Therefore it is intended that each film strip be considered a standard only for the defect under consideration.

Correlation of Films and Tests:

General experience, guided bend tests, tension tests, and X-ray interpretation show remarkably good agreement. X-ray interpretation with respect to grading was very satisfactory even though the number of specimens was small. If the generally accepted practice of rejecting all cracks is accepted, then the grading of the standard will serve simply as an aid to the inspector. Since scattered porosity appears to have no effect on strength as determined both from tension and bend tests, it should be acceptable in all grades. The occasion might arise where either the guided bend or the tension test might be preferred; consequently in the standards which are reproduced completely in the Appendix, the conclusions from both types of tests are given.

Metallurgical Confirmation:

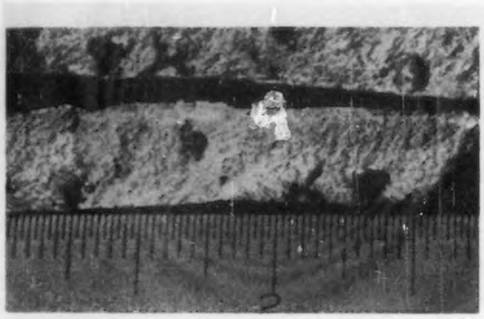
In order to reveal the true nature of the defects which radiography had detected, five specimens were photographed at two diameters magnification after failure in bend test. Using the established code the bend test specimens photographed are: 81 A-R, 85 B-R, 126 C-R, 132 E-R, and 92 K-F. Also, specimens containing degree 3 of each defect except G were sectioned across the weld, deep etched with sodium hydroxide, and photographed at $\times$ 2 magnification. The photographs appear in the

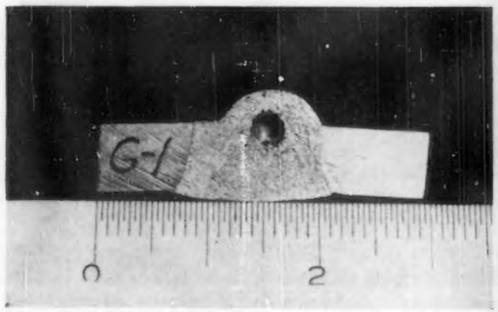


Grade 1 | Grade 2 | Grade 3 | Grade 4 | Grade 5

GAS HOLES, ASTM 6.33.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
		BEND TEST		
0% Failed Acceptable	0% Failed Acceptable	50% Failed Rejectable	75% Failed Rejectable	67% Failed Rejectable
		TENSION TEST		
99% U. S. 13% Elongation Acceptable	96% U. S. 9% Elongation Acceptable	% U. S. % Elongation Rejectable	89% U. S. 13% Elongation Rejectable	86% U. S. 10% Elongation Rejectable





Appendix as part of the book of radiographic standards.

It can be seen that the defects which lead to failure in nearly all degrees are those located at the root of the weld; that is, lack of penetration, dross, and linear porosity. The sharp line transition zone is clearly defined, but the bend tests indicate that fusion is complete. It is also seen that cracks and lack of penetration intersect the surface in every case.

In several cases, dross inclusions have affected the test result. Occasionally the dross is in the form of an oxide film difficult to detect on the radiograph and considerable caution and experience are required by the film interpreter as this defect lowers the physical properties markedly. On the other hand, gas holes which show a bright, clean surface on fracture do not appear to affect the weld quality except by the amount of reduced cross-section.

Superficial hardness tests were made using the R 15 T scale and the averages of three readings from five specimens are as follows:

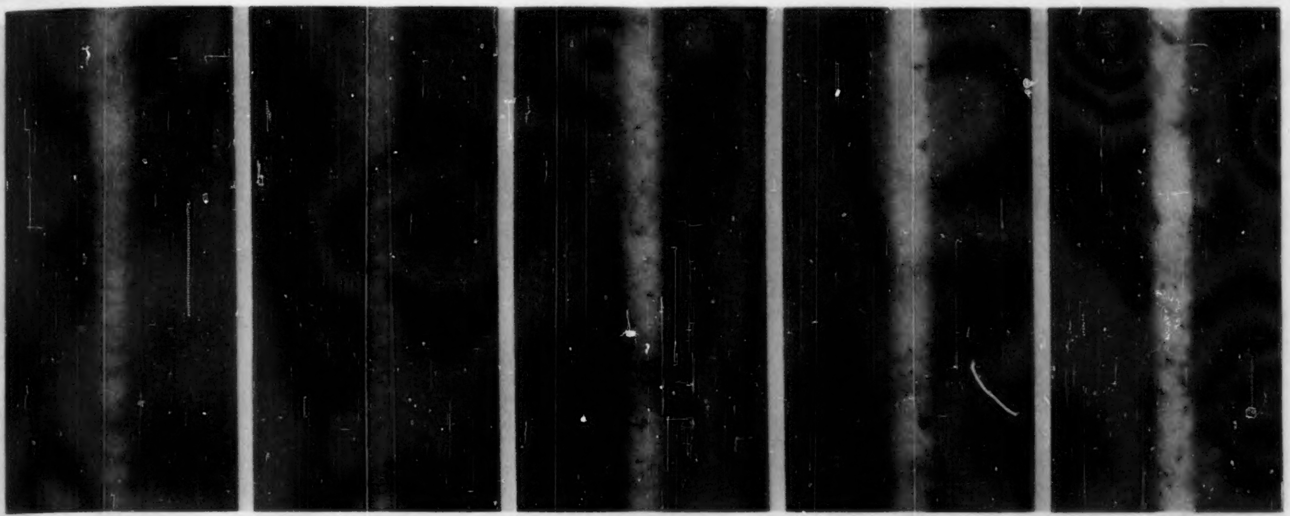
Base metal before test.........	50
Base metal after failure in tension..........	55
Weld metal before test.........	53
Weld metal after failure in tension.......................	57

No difference was detected in the weld metal where 2S or 43S filler material was used. These data lead one to expect tension failure to occur outside the weld zone given equal areas and an absence of rejectable defects.

Book of Standards:

The end result of this investigation is a collection or book of graded evaluated standard films. The primary purpose of such a book of standards is to enable quality and workmanship to be accurately specified in purchase contracts and to provide the inspector with a criterion for acceptance. The latter purpose is best served by standard films rather than by printed reproductions or paper prints such as are used in the Appendix of this report. Accordingly the "X-ray Standards for Shielded Arc Welds in Aluminum" are reproduced on films in which the contrast gradient of the original radiographs is retained. These standards have been carefully prepared according to a procedure developed previously[7] and have been delivered separately to the project originator.

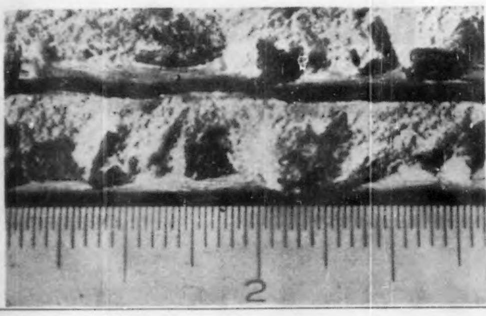
Standard terminology for the description of classes of defects as outlined in ASTM terminology E 52–49 T[8] has been used in the interest of accuracy and clarity. ASTM defect code num-

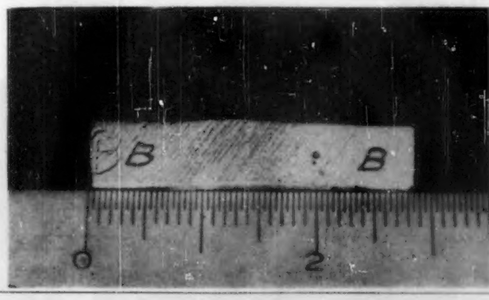


Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

SLAG, DROSS, ASTM 6.4.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Bend Test				
100% Failed Rejectable	100% Failed Rejectable	58% Failed Rejectable	80% Failed Rejectable	91% Failed Rejectable
Tension Test				
99% U. S. 16% Elongation Acceptable	87% U. S. 13% Elongation Rejectable	57% U. S. 11% Elongation Rejectable	% U. S. % Elongation Rejectable	70% U. S. 8% Elongation Rejectable





bers are given for each defect and may be used in inspection reports for brevity in replacing the descriptive defect titles.

Conclusion

Summary of Results:

A set of X-ray standards for shielded arc welds in aluminum has been established on the basis of guided bend and tension tests of 300 specimens. Agreement between the two types of tests was good. It was concluded that all grades of incomplete penetration, dross, and cracks should be considered rejectable; that scattered porosity and tungsten inclusion do not significantly reduce strength, and that the intermediate and more severe grades of linear porosity and gas holes should be considered rejectable. A book of film standards has been prepared incorporating a summary of the test data. Although the specimens were prepared by Heliarc welding of ¼-in. 3S aluminum plate over a grooved steel back-up bar, the standards are intended to apply to all similar types of shielded arc welding in 2S and 3S aluminum plate and particularly to mine case welds.

Recommended Future Work:

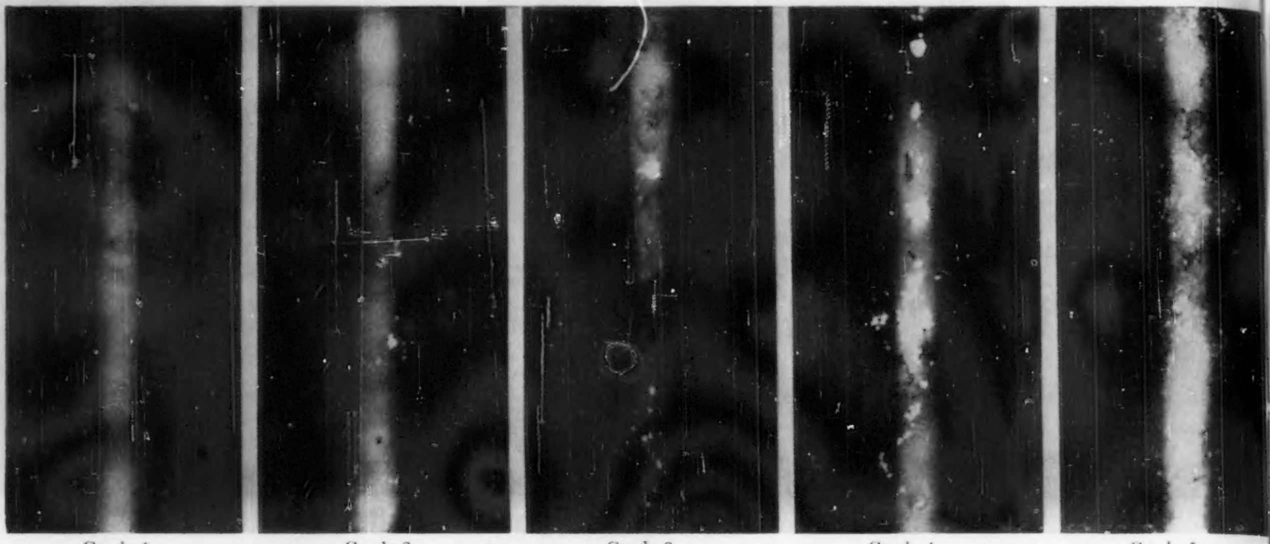
There are a number of areas where future work could prove most valuable. From the point of view of insuring serviceable mine cases, probably the most advantageous work would be the establishment of standards for gas welding of aluminum. This is particularly true since the choice of arc or gas welding is left entirely to the mine case manufacturer. Mine case standards covering both gas and arc welding of steel are urgently needed. There is also need for standards on the heat-treatable aluminum alloys, although the Bureau of Ships standard fills the major requirement there. Finally, the very important field of strength variation with joint and weld design is of prime importance and interest to those responsible for engineering designs. Further work along any of the lines mentioned should prove very fruitful.

Acknowledgment:

The degree of success attained in this project is largely due to the skill displayed by the welder, M. J. Shuck. The Technical Shop not only provided his services, but also obtained and temporarily installed in the X-Ray Laboratory complete Heliarc welding equipment. The services of C. G. Thornhill were invaluable.

[7] D. T. O'Connor and L. V. Burt, "A Procedure for Reproducing Radiographs," (Naval Ordnance Laboratory Memorandum #10711), Jan. 12, 1950.

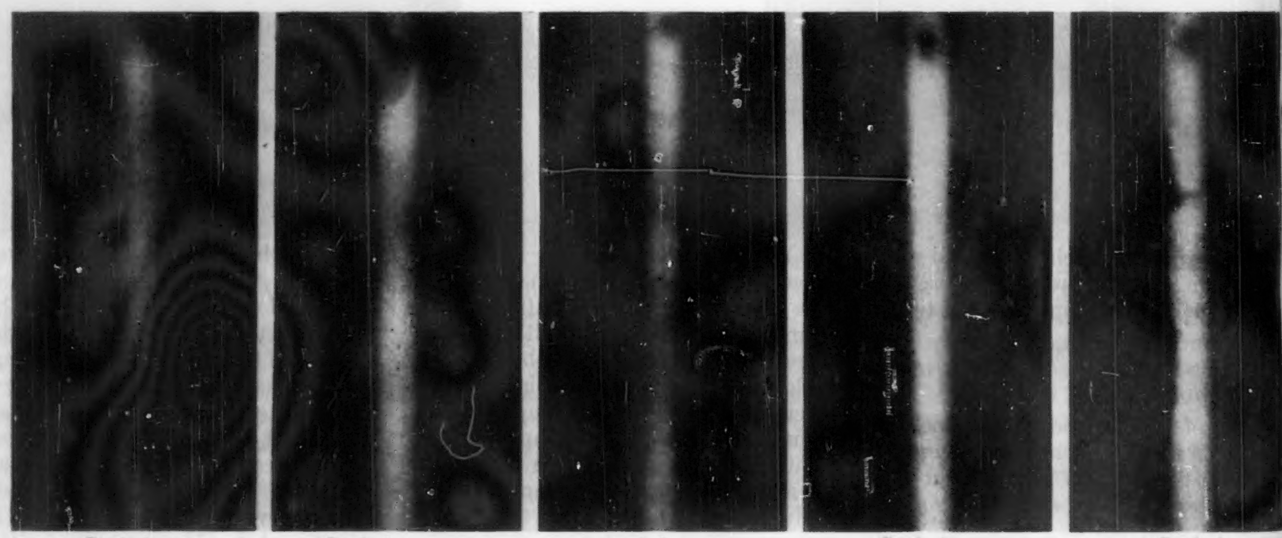
[8] Tentative Industrial Radiographic Terminology for Use in Radiographic Inspection of Castings and Weldments (E 52–49 T), 1949 Book of ASTM Standards, Part 1, p. 1329, Part 2, p.1070.



Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

TUNGSTEN INCLUSIONS, ASTM 6.41.

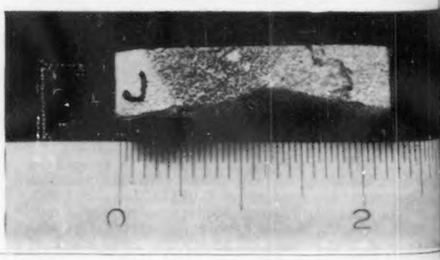
Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
		BEND TEST		
0% Failed Acceptable	0% Failed Acceptable	0% Failed Acceptable	0% Failed Acceptable	0% Failed Acceptable
		TENSION TEST		
99% U. S. 12% Elongation Acceptable	94% U. S. 13% Elongation Acceptable	97% U. S. 7% Elongation Acceptable	99% U. S. 8% Elongation Acceptable	81% U. S. 10% Elongation Rejectable

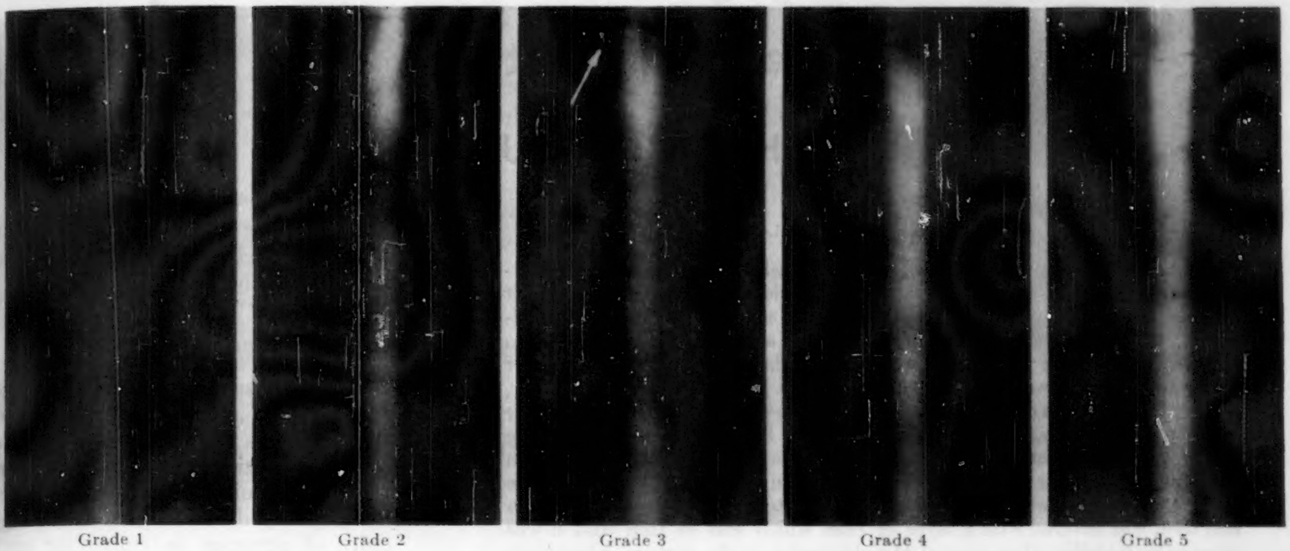


Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

CRATER CRACKS, ASTM 6.5.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Rejectable	Rejectable	Rejectable	Rejectable	Rejectable

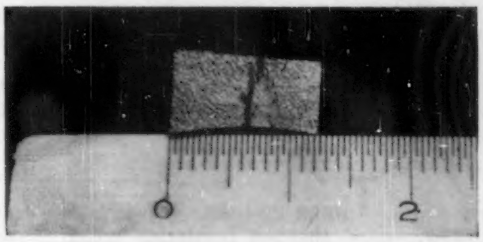




Grade 1 Grade 2 Grade 3 Grade 4 Grade 5

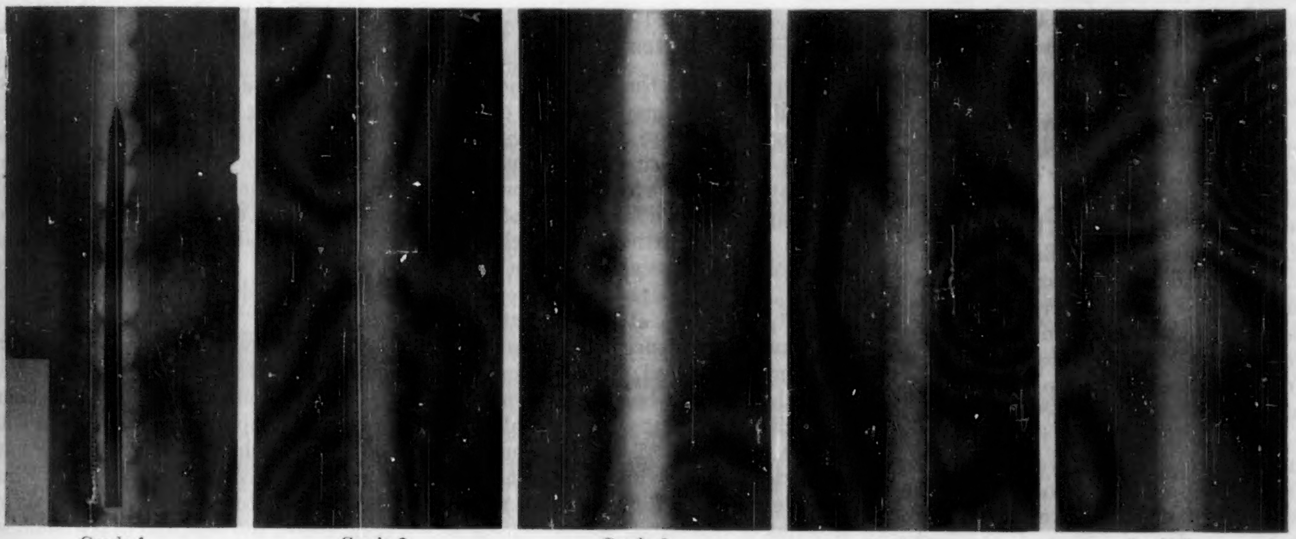
TRANSVERSE CRACKS, ASTM 6.51.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Rejectable	Rejectable	Rejectable	Rejectable	Rejectable

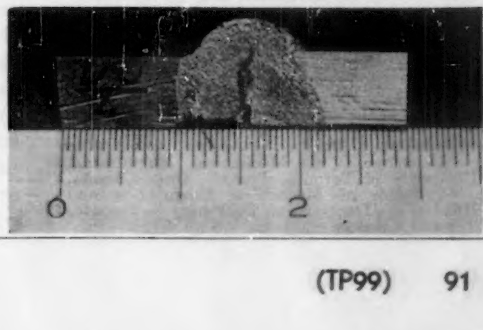


LONGITUDINAL CRACKS, ASTM 6.52.

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Rejectable	Rejectable	Rejectable	Rejectable	Rejectable



Grade 1 Grade 2 Grade 3 Grade 4 Grade 5



The Influence of Aging Factors on the Emissivity of Reflective Insulations

By F. C. Hooper[1] and W. J. Moroz[1]

Foreword by E. A. Allcut.[2]

The idea of using metallic surfaces of low emissivity for reducing or inhibiting the transmission of radiant heat has a considerable popular appeal, as it is widely employed in household appliances and scientific apparatus. In addition, it is light, clean, and not very difficult to apply. Its usefulness as an insulator in building practice, however, depends on the length of time for which the material will retain its characteristic properties. In a building, even if the surface is continuous, it is exposed to dust, moisture, and possible frosting or corrosion, and various reports have been received from time to time regarding the seriousness or otherwise of these factors. About thirteen years ago, the writer made a series of tests on an air space of which one face was covered with metallic foil. This was first tested in the clean condition and then was covered with a layer of dust which was so thin that it was practically invisible when viewed at right angles to the surface, whereupon the conductance of the panel increased by about 13 per cent. The investigation described in this paper was an extension of that experiment and was designed to indicate the amount of deterioration that might be expected in practice. The first step, obviously, was to design and make a suitable apparatus for the experimental work. As far as was known, no standard apparatus existed for the purpose. The work was performed in the Mechanical Engineering Laboratories at the University of Toronto.

There has been a growing use of types of thermal insulation which derive their effectiveness from their low radiant heat transmission properties. These materials are generally described as reflective insulation. Their effectiveness, technically, depends upon that property defined as the total normal surface emissivity.

Occasional reports have been made on the apparent deterioration with age of the insulating property of such material. These reports, and an increasing number of inquiries on the durability of the reflective insulations under various conditions of exposure, have indicated the necessity for more definite data on this subject. An investigation was undertaken at the University of Toronto in an attempt to provide such information.

The objectives of the initial investigation reported here were threefold. First, it was necessary to establish the existence of deleterious effects due to various conditions. Second, the probable order of magnitude of any deleterious effects, so revealed, was to be determined. Last, it was hoped that the experience gained from the construction and use of specialized testing equipment for this purpose would contribute toward the ultimate establishment of standard procedures for use in similar tests.

Significance of Tests

The pursuit of the above objectives necessitates an investigation of the progressive increase in emissivity resulting from exposure to various contaminating or corrosive conditions. It also requires the establishment of techniques for the artificially accelerated aging of the reflective insulation specimens. The investigation here reported did not, in general, attempt to establish the time equivalence of the artificial aging methods used. Indeed, such an equivalence would be applicable only to a specified installation and could not readily be generalized. Because of this indeterminate time factor, it is not possible directly to interpret the results in terms of quantitative time effects in actual applications.

The maximum deterioration due to any one factor was not determined in these tests, for in many cases the maximum effect would be the ultimate destruction of the material. Since no uniform criterion for the severity of contamination could be found, it was possible to age the specimens under artificial conditions consistent only with intuition and experience. Because of this indefinite arrangement, the aging method used for each test reported will be separately described.

Technique of Measurement

A form of test apparatus was devised to meet the specific requirements of this project. The following were the principal considerations in the design:

1. To permit a usefully high accuracy of emissivity determination and a high order of accuracy in emissivity comparison.
2. To provide a suitable isothermal surface for the mounting of specimens.
3. To provide convenient means of control and measurement of surface temperature.
4. To permit attaching specimens of a size large enough to be representative of general surface conditions.
5. To ensure reproducibility.
6. To provide means for direct calibration before each reading in order to minimize errors due to instrument drift.

To meet these requirements the form of apparatus shown in Figs. 1 and 2 was devised.

The double shell construction permitted filling of the cavity with a fluid which, being in contact with all outer surfaces of the inner chamber, could provide isothermal conditions in the inner chamber. This chamber was blackened on its inner surfaces. The aperture size corresponded to the cone of sensitivity of the radiation thermopile.

The immersion heater was used to control the temperature of the fluid in the cabinet. The cavity, being open at the top, could also be filled with low-temperature ice mixtures. Manual stirring proved necessary only when such ice mixtures were in use. Temperatures of the fluid and of the chamber were measured by a calibrated mercury thermometer. The specimen mounting surface was on heavy aluminum plate, and as it was in contact on its inner face with the fluid in the cabinet, it provided a suitable isothermal plane against which foil specimens could be mounted. Specimens were caused to adhere to this face by means of an air suction arrangement consisting of a low-vacuum, high-capacity pump draw-

Note.—Discussion of this paper is invited, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

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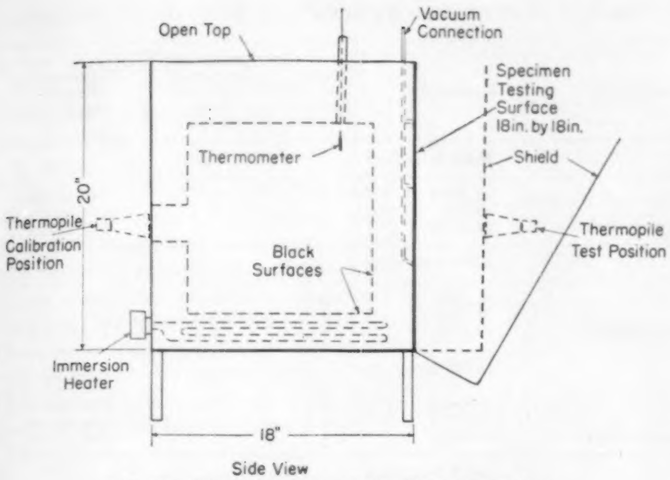

Fig. 1.—The Structure of the Test Apparatus.

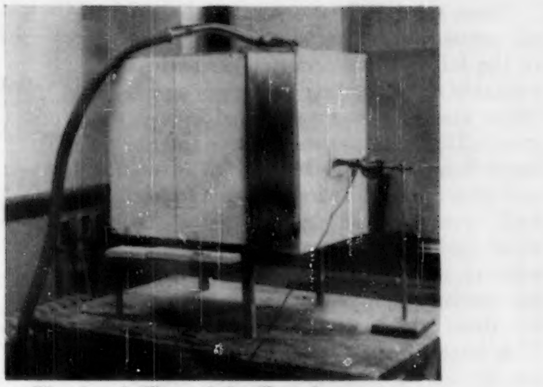

Fig. 2.—A View of the Test Apparatus.

ing through a series of tubes connected to grooves ground in the outer surface of the plate. Thus the specimens were firmly held by atmospheric pressure. This arrangement is not adaptable to porous or rigid specimens, but permits rapid specimen changes and avoids the necessity for touching the prepared surface which arises if adhesives are used.

The screen opposing this face, blackened on its inner surface, provided a shield against stray radiation.

The radiation thermopile used is a commercially available laboratory instrument fitted with a shielding cone and containing six exposed junctions. This instrument was calibrated directly against the black body radiation from the isothermal chamber.

The thermopile potential was read on a type K potentiometer which was adequately sensitive for the range of radiation intensities encountered.

The technique of testing was to fit the prepared foil specimen to the test surface after the cabinet had been brought to test temperature. A black body radiation thermopile reading was then taken on the isothermal chamber, and immediately a second reading was made on the foil surface.

The ratio of the emf readings so obtained, when corrected for the temperature drop between the chamber fluid and the foil surface, was taken as the effective total normal emissivity.

This value is the measure of the effectiveness of reflective insulation. The lower the emissivity the more effective is the insulating performance. Emissivity can vary from zero to unity.

These test arrangements were found to be reasonably convenient and satisfactory for the large number of separate test determinations which are entailed in an investigation of the type undertaken.

Specimen Preparation and Test Results

The test results are conveniently divided into separate groups. These include results on the following:

1. Specimens in new condition and results of general comparison tests. 2. Specimens prepared by spraying with weak solutions. 3. Specimens prepared by direct exposure to atmospheric conditions. 4. Specimens exposed to air spaces faced with fresh plaster. 5. Specimens upon which condensation or frost was present.

Group 1:

This group includes only control tests. They were made to assist in the assessment of the absolute accuracy of the tests. The values obtained are shown in Table I. Except for the plain foils, these values agree within 2 per cent with those obtained by other investigators (**1, 2**).

Variation of emissivity with temperature is small within the limited temperature range of the tests. The highest and lowest surface temperatures at which determinations were made are shown in the table. The average deviation from the mean within each series of tests is also indicated. A part of the dispersion of results so indicated is random error while the balance is attributable to the temperature effect already mentioned.

The "new" foils were taken directly from the inner layers of rolls of the material. The foils of manufacturers A and B give a regular reflection from either face. Foils of manufacturer C are produced by an oil rolling process and give diffuse reflection from the "dull" face.

The lampblacked surface was prepared by painting a smooth foil surface with a heavy coat of lampblack in an alcohol suspension. The coat of white oil-base paint was uniformly deposited on a smooth foil and allowed to dry. The heavy brown wrapping paper was of the regular commercial type.

Group 2:

Table II tabulates the results obtained from specimens prepared by spraying with weak solutions. Foil from manufacturer A was used in each case. This spray technique was used in an attempt to duplicate the effect of atmospheres contaminated with the solutes employed. Five such solutions, all of low concentration, were used. These were:

KOH solution 0.146 normal
NaOH solution 0.034 normal
CaOH solution 0.054 normal
H_2SO_4 solution 0.308 normal
NaCl solution 0.6 per cent molal concentration

TABLE I.—GROUP 1, SPECIMENS IN NEW CONDITION AND GENERAL COMPARISON TESTS.

Specimen	Emissivity	Number of Tests	Average Deviation from the Mean, per cent	Temperature Range, deg Fahr
New foil, manufacturer A	0.0516	6	1.7	173 to 198
New foil, manufacturer B	0.0646	4	4.2	146 to 190
New foil, manufacturer C, bright side	0.0300	5	12.5	200 to 202
New foil, manufacturer C, dull side	0.0242	4	4.6	208 to 204
Lampblacked surface	0.934	7	2.6	114 to 200
White oil-base paint	0.939	6	1.0	173 to 194
Heavy brown wrapping paper	0.902	5	1.2	192 to 200

These solutions were sprayed by an air pressure atomizer onto the surface of the foil in a uniform manner and in amounts not exceeding 0.05 g per sq in. Three specimens were prepared in each case. The first was sprayed once and allowed to air dry before testing. The second was sprayed twice, air dried after each spraying, and then tested. The third specimen was prepared in the same manner as the second but was then successively sprayed with water and air dried three times before testing. This latter procedure was to determine the extent of reactions which might result from re-solution of the dried solutes left on the specimen. An increase in the emissivity between the second and third specimens would indicate a latent chemical reaction. These water sprayings also tended to remove lightly deposited solids remaining after the evaporation of the solvent in the initial sprayings.

An extra test on the effect of eight sprayings of water, with air drying after each spraying, was made to determine the influence of the water itself on the emissivity changes observed.

Group 3:

Specimens of foil (manufacturer A) were directly exposed to both indoor and outdoor atmospheres. The majority of the outdoor specimens were too badly damaged physically by tears and wrinkles to permit testing on the form of apparatus employed. Nothing was done to accelerate the aging of these specimens. The results are tabulated in Table III.

The results obtained on specimens exposed indoors are somewhat at variance with those reported by other investigators (**3, 4**).

Group 4:

A specimen of foil from manufacturer C was placed in a frame in such a manner that either side faced across a 1-in. gap the rear surface of freshly plastered expanded metal lath. The drying was allowed to proceed for one week in a building which was being plastered. After removal for test of the original specimen, a new specimen of foil was placed in the test frame and exposed in a saturated atmosphere at a temperature of about 120 F for two days. These tests are summarized in Table IV.

Group 5:

The effect of accumulations of moisture condensed from the atmosphere, and of frost sublimation, on the emissivity of foil surfaces was examined. In these tests the cavity was filled with a mixture of ice and water, with salt added for the frosting tests. All foils used in these tests were from manufacturer A.

TABLE II.—GROUP 2, SPECIMENS PREPARED BY SPRAYING WITH WEAK SOLUTIONS

Manner of Contamination	Emissivity	Number of Tests	Average Deviation from the Mean, per cent	Temperature Range, deg Fahr
NaCl Solution				
1 spraying	0.0707	4	13.7	145 to 206
2 sprayings	0.064	5	4.1	174 to 202
2 sprayings with 3 sprayings H_2O	0.0778	4	3.7	162 to 172
KOH Solution				
1 spraying	0.176	10	4.8	128 to 206
2 sprayings	0.433	4	6.5	136 to 154
2 sprayings with 3 sprayings H_2O	0.345	8	2.6	173 to 188
NAOH Solution				
1 spraying	0.0610	4	4.5	160 to 196
2 sprayings	0.0636	4	5.2	192 to 199
2 sprayings with 3 sprayings H_2O	0.0621	4	1.1	180 to 193
CaOH Solution				
1 spraying	0.0588	7	4.8	195 to 202
2 sprayings	0.0843	11	21.6	110 to 204
2 sprayings with 3 sprayings H_2O	0.0960	7	3.9	201 to 206
H_2SO_4 Solution				
1 spraying	0.238	9	2.5	136 to 183
2 sprayings	0.366	6	2.6	112 to 200
2 sprayings with 3 sprayings H_2O	0.0825	4	4.7	187 to 197
1 very heavy spraying of H_2SO_4 solution	0.552	5	3.9	115 to 170
8 sprayings H_2O on bright foil	0.0621	4	2.0	192 to 199

TABLE III.—GROUP 3, SPECIMENS PREPARED BY DIRECT EXPOSURE TO ATMOSPHERIC CONDITIONS.

Manner of Exposure	Emissivity	Duration of Exposure, days	Number of Tests	Average Deviation from the Mean, per cent	Temperature Range, deg Fahr	Remarks
0.0005-in. foil in vertical position out of doors, stapled to hard surface	0.0652	34	5	13.3	137 to 203	11 days with rain. Some pinholes and creases in surface due to wind action
As above	0.0711	55	5	2.2	124 to 202	16 days with rain
Vertical specimen open to air in quiet part of laboratory	0.0681	92	5	3.3	187 to 194	Visible dust on surface
Horizontal specimen in same location in laboratory	0.149	98	6	3.5	186 to 200	Considerable dust on surface. Did not fall off when specimen moved and shaken

TABLE IV.—GROUP 4, SPECIMENS EXPOSED TO AIR SPACES FACED WITH FRESH PLASTER.

Specimen Exposure	Emissivity	Duration of Exposure, days	Number of Tests	Average Duration from the Mean, per cent	Temperature Range, deg Fahr
Foil of manufacturer C, bright side toward plaster	0.0611	7	5	5.7	194 to 201
Dull side of above specimen toward plaster	0.0920	7	8	5.6	138 to 184
Foil of manufacturer A, facing plaster under high humidity conditions at about 120 F	0.287	2	7	2.3	168 to 177

Typical results are shown in Fig. 3. These include the effect of frosting on surfaces of both high and low initial emissivity.

Discussion and Conclusion

The limitations to accuracy in this investigation are imposed by the uncertainties associated with the preparation of the specimens rather than by the precision of emissivity measurement. Thus, while some small errors are present due to the form of apparatus and the measurement techniques employed, they are of a low order of magnitude and do not appear to influence the significance of the conclusions. This view is supported by the good agreement

of the comparative tests of Table I with results reported by other investigators, and by the generally low deviations from the mean within the various test series.

The results obtained from specimens subjected to accelerated aging with sprayed solutions of common atmospheric contaminants indicate that exposure to any of these solutes reduces the effectiveness of the insulation to some extent. The most marked reductions were found with solutions of H_2SO_4 and KOH. The effect of spray washing varied with the solutes as can be seen from Table II.

Outdoor specimens show an increase of emissivity with time, although results were somewhat obscured by physical damage due to wind action. Specimens exposed to indoor conditions accumulated dust in both horizontal and vertical positions. In both cases, significant increases in emissivity accompanied this dust accumulation.

A definite increase in emissivity of foil due to exposure to wet plaster under typical building construction conditions was noted. A very marked effect was observed under high humidity conditions.

The effect of accumulations of condensed water on the surface of foil is shown in Fig. 3. It is seen that the emissivity rises steadily to a maximum of approximately 0.8 indicating that a total loss of effectiveness results under conditions which permit progressive condensation.

Frosting of the surface shows a similar effect. The final emissivity

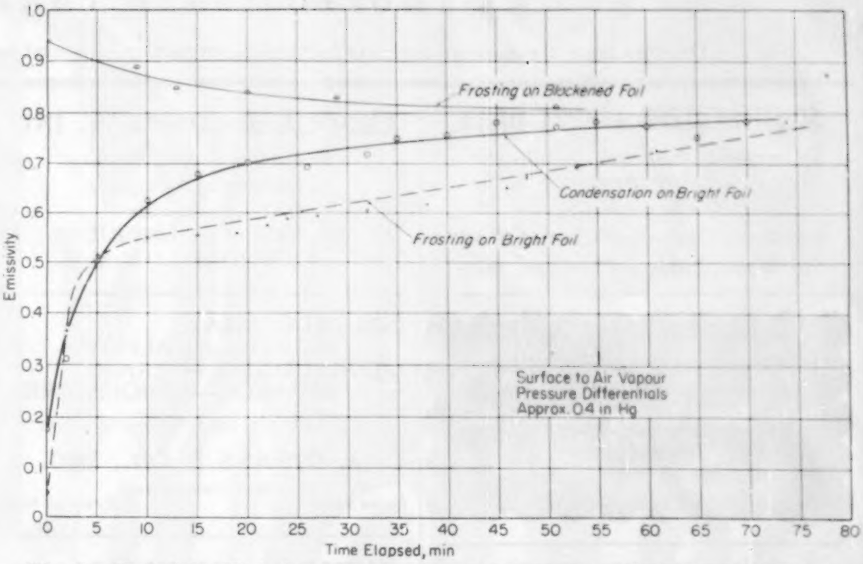

Fig. 3.—Emissivity Variations Due to Accumulations of Condensation and Frost.

is independent of the surface upon which condensation or frosting occurs as demonstrated by the asymptotic behavior of the curves of Fig. 3. The apparent maximum emissivities for these tests are probably low because of the insulating effect of the accumulations themselves. Correction for this effect was not attempted.

In general, it seems apparent that under many common conditions of use the aging of reflective insulation will be accompanied by a reduction in its insulating value. It must be understood that this investigation has demonstrated only the existence and not the specific magnitude of the effects which accompany aging.

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(1) E. R. G. Eckert, "Introduction to the Transfer of Heat and Mass," McGraw-Hill Book Co., Inc., New York, N. Y. (1950).

(2) W. H. McAdams, "Heat Transmission," McGraw-Hill Book Co., Inc., New York, N. Y. (1942).

(3) C. S. Taylor and J. D. Edwards, "Some Reflection and Radiation Characteristics of Aluminum," *Proceedings*, Am. Soc. Heating and Ventilating Engrs., Vol. 45 (1939).

(4) G. B. Wilkes, "Reflective Insulation," *Industrial and Engineering Chemistry*, Vol. 31, p. 832, July, 1939.

Engineers, and Engineers!

Someone has said that it takes all kinds of people to make up this old World, and along somewhat similar lines, we guess it takes all kinds of engineers to make up the engineering profession, although frankly we cringe a bit on that word "profession" when we consider a recent request received from a Project Engineer on a housing job. This particular chap had something that he wanted to get settled in his mind.

Quoting from the communication:

> "I would like to know what nonferrous metal is, as we have had some differences in opinion here on the project as to the painting of exposed water pipe.
>
> "Is copper pipe non-ferrous metal? Your information on the above will be appreciated, and if there is any cost in connection therewith, please bill the same to me personally."

Some information was sent off to this "engineer," complementary from the more than 7000 members comprising the ASTM.

Mosquito Australia's Hope in War on Rabbits

A note from the Wool Bureau in New York describes how the mosquito is carrying on a full-scale "germ warfare" in Australia's critical efforts to control the rabbit menace. Apparently a virus disease "myxomatosis" can be spread by certain species of mosquitoes, and this is very fatal to rabbits, spreading rapidly both in the open and in burrows. This virus is reputed to be harmless to all other animals.

It is estimated there are almost two billion rabbits in Australia, and with seven rabbits consuming about as much grass in one day as the average sheep, the seriousness of the situation is obvious. The release concludes: "to assess the tremendous job facing Australia's wool growers, it is pointed out that one pair of rabbits can produce 534 offspring in a year; in three years the progeny of these 534 rabbits will total nearly 14 million."

Proceedings of the Institution of Mechanical Engineers

Volume 163 of the *Proceedings* is comprised of W.E.P. Nos. 55–62 which were not included in the general *Proceedings*. In the more than 25 papers and discussions included in this volume are two papers which should be of special interest to ASTM members: "Caustic Cracking: Stress Corrosion Tests in Sodium Hydroxide Solution at Elevated Temperatures," by C. D. Weir; and "The Use of Mild Steel for Service at Subzero Temperatures," by F. H. Keating and E. V. Mathias.

Copies of this volume can be obtained from the Institution at Storey's Gate, St. James's Park, London, S.W. 1.

PROFESSIONAL CARDS

On this page are announcements by leading organizations and individuals of their services.